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# LEARNING TO DEVELOP INNOVATIONS

Individual competence, multidisciplinary  
activity systems and student experience

Laura-Maija Hero



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# **Learning to develop innovations**

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multidisciplinary activity systems and  
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*To the most loved ones: Hilda, Totti and Jyrki.*

*To those teachers, students and work organisations  
collaborating while trying to learn together to make  
the world a better place for all.*



# Abstract

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This dissertation studies learning to develop innovations in the context of universities of applied sciences. The aim is to increase theoretical and empirical understanding of the phenomenon that can be used in tutoring, planning and organising the multidisciplinary innovation development collaboration between education and working life. Research related to innovation development learning has mainly focused on organisational perspectives, even in the context of education. Earlier research has not focused in depth on learning from multidisciplinary perspective. To this end, three qualitative sub-studies were conducted that focused on aspects of learning; namely, the learning outcome as individual innovation competence, the characteristics of activity system and students' learning experiences in the activity.

Innovations are needed to benefit business, solve difficult problems faced by society and to ease the everyday lives of ordinary people. Although there is a long history of innovation defined as disrupting technological novelties with a business benefit, innovations are important in all professional fields. An innovation is a useful novelty that is made concrete and implemented to convey value. The value innovations create is tied to novelty values, but also the benefits for the user, but it can also be tied to more widespread areas of value-creation (e.g. economic, wellbeing, sustainability, or social). Multidisciplinary collaboration is related to the development of innovations, as the need for new solutions springs from complex problems in societies or from the underlying needs of people. Complex problems benefit from diverse perspectives and complementarity of competence in complex systems and processes.

Sub-study I was a systematic review that collected 10 years of research article material on individual innovation competence based on extraction criteria formed based on a preliminary scoping review. Sub-study II was an activity system analysis of one year's video material of teachers' meetings while they were planning and piloting two new types of multidisciplinary innovation project courses. Sub-study III was a phenomenographic study of student diaries (N = 74) written during three

multidisciplinary innovation project course implementations. The data was analysed through data-driven content analysis (sub-studies I and III) and part-to-whole deductive content analysis based on an activity system model (sub-study II). Several methods to enhance the rigor of the research were applied (e.g. a blind cross-review and three-author-bias assessments). In the general parts of the dissertation, the main research question could be answered by combining the results of the sub-studies.

The findings from sub-study I suggested that personal characteristics such as flexibility, achievement orientation, motivation and engagement, self-esteem and self-management, future orientation, creative thinking skills, social skills, project management skills and content knowledge and making skills are all required for collaborative innovation processes. Sub-study II found tensions and solutions in teachers' development collaboration that concerned the subject to be learned and community formation, as well as in the tournament object formation related to tasks, ways of working, assessment methods and the challenges from work organisations. The study also found solutions for tournament-based multidisciplinary innovation project rules, the division of labour and tools such as processes, methods for choosing the winners, prizes, assessment criteria and the technical tools. The findings from sub-study III suggested that students understand their learning experience in relation to solvable conflicts and unusual situations they experience during the project while becoming aware of and claiming their collaborative agency and internalising phases of the innovation process. The competences that students could name as learning outcomes related to content knowledge, different personal characteristics, social skills, emerging leadership skills, creativity, future orientation, social skills, technical, crafting and testing skills and innovation implementation-related skills such as productisation, marketing, sales and entrepreneurship planning skills. However, future orientation and implementation planning skills were weaker than the other variables in the data were.

The dissertation concludes with the factors related to learning to develop innovations based on the sub-studies. First, the factors related to individual innovation competence based on sub-studies I and III are personal characteristics such as self-esteem, self-management, achievement orientation, motivation and engagement, flexibility and responsibility, future orientation, creative thinking skills, social skills such as networking, collaboration and communication skills, development project management skills such as leadership skills (e.g. actively building team competence, encouraging and coaching others), one's own and other's discipline content knowledge, and concretisation and implementation planning skills such as making, productisation, sales, marketing and entrepreneurship planning.

Second, several pedagogical development phases and assessment opportunities were suggested in a theoretical model of a pedagogical innovation process: orientation and theory, creative idea development, future orientation, concepting, prototyping and testing, and implementation and entrepreneurship planning phases. Multiple assessment phases are integrated in the model. Organising an authentic, explicitly- or implicitly-

facilitated pedagogical innovation process may promote more complete outcomes as it pursues implemented novelties and provides for more transparency in terms of learning. In multidisciplinary innovation projects, the most important factor for learning seems to be the journey, not the actual outcome or whether it is or is not an innovation in terms of the mere definition of the word. By acknowledging the strengths, weaknesses and competence development needs of the participating students in multiple phases, it is possible to discover the opportunities provided by the complementarity of knowledge and to support individual student learning in teams. The competence model is suitable for steering peer discussions and for developing practical collaborative tools for assessment.

Third, in addition to competence factors, several factors related to individual participants were highlighted for teachers to recognise while tutoring multidisciplinary teams based on sub-studies II and III. Those include the levels at which students can take responsibility, students being dependent on teachers' guidance (which is related to student motivation), and how much conflict and how many contradictory situations students can handle without losing motivation.

Fourth, while organising for learning to develop innovations, several preconditions can be recommended based on the findings. A multidisciplinary activity system may support innovation learning if it allows for optimal conflict and contradiction, new networks and teams, and opportunities to recognise competence. The multidisciplinary composition of teams allows for the complementarity of competence and enables students to recognise their own expertise. Competence shows in authentic contexts and it should have an intention related to action. The intention can be an open task to develop an innovation in terms of the definition. An open task from working life or other real-life context that allows for a novel solution with implementation planning is thus needed to guarantee an authentic learning experience, networks and a need for students from different disciplines. A multidisciplinary team composition can allow for the shift from "I" thinking in learning to "we" thinking. Students reported on how they had learned to encourage and coach others, to consciously change their attitude for the benefit of the team's wellbeing and even to deliberately give up leadership positions to help others learn management. The individual differences between people and the heterogeneity of the participants in the collaborative action were noted as leading to a positive breaking down of barriers, thus catalysing competence development and innovation process internalisation. Multidisciplinary innovation projects are pedagogical ways to connect schools to the practices of society, as already suggested by Dewey.

Based on the sub-studies, the teacher's role is not to make him or herself not needed. Teachers should promote deep comprehension of the innovation process, monitor and ease the pain of conflict if it threatens motivation, offer assessment tools and help in recognising gaps in individual competences and development needs, promote more future-oriented, concrete and implementable outcomes, facilitate the solution development networks and facilitate in bridging innovation and entrepreneurship

planning if this opportunity emerges. Using a competence model as a tool to frame the peer-assessment discussions instead of absolute quantitative proof of learning may allow students to immerse themselves fully in project work experience, but still discover their learning needs in the beginning and achieve learning outcomes during and after.

*Innovation* seems like a useful concept to be applied in educational conditions when the outcome of students' work is not required to be pre-determined, when the students are encouraged towards creative outcomes with original novelty value and empowered to reach for their full capacity and exceed it by learning, when the importance of aiming at concrete and useful outcomes such as products, services, processes or other concretised artefacts is emphasised, when the students are encouraged to plan the implementation (commercially or otherwise) to be taken into use to convey value, when the value in authentic experiences is required to be grasped by students' working as part of society (not only inside school buildings) by learning together with their potential future employers and in real networks. Innovation pedagogy seems to be a useful and a valid term to be applied when the aim is to define and practice innovation development activities as purposive cultural interventions in networked and multidisciplinary collaborations for human development informed and shaped by the real values and history of the society, and when the target is to develop a novelty that is made concrete and implemented to convey value.

Keywords: Individual innovation competence, multidisciplinary, innovation pedagogy, activity system, learning experience, pedagogical innovation process, higher education, professional higher education, university of applied sciences

# Tiivistelmä

**Laura-Maija Hero**

*Innovaatioiden kehittämisen oppiminen. Yksilön kompetenssi, monialaiset toimintajärjestelmät ja oppimiskokemus.*

Kasvatustieteellinen tiedekunta, Turun yliopisto.

Kasvatustiede, oppimisen, opetuksen ja oppimisympäristöjen tutkimuksen tohtoriohjelma (OPPI)

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Tämä väitöskirja tutkii innovaatioiden kehittämisen oppimista ammattikorkeakoulun kontekstissa. Tutkimus määrittelee opetussuunnitelmatyön ja pedagogisen suunnittelamisen kannalta keskeisiä muuttujia eli innovaatioiden kehittämiseen liittyviä kompetensseja sekä toimintajärjestelmän ja prosessien erityispiirteitä. Se pyrkii teoreettisesti ja empiirisesti edistämään työelämäyhteistyössä toteutettavan innovaatioiden kehittämisen oppisen optimaalista suunnittelua ja organisointia.

Tämän tavoitteen saavuttamiseksi toteutettiin kolme osatutkimusta. Ne keskittyivät tavoiteltavien oppimistulosten määrittelemiseen yksilötason innovaatiokompetensseja selvittämällä sekä toimintajärjestelmän luonteen ja opiskelijan kokeman oppimisen erityispiirteiden ymmärtämiseen. Innovaatioiden kehittämiseen liittyvän oppimisen tutkimus on pääasiassa keskittynyt organisaatiotason näkökulmiin, jopa kasvatustieteiden kontekstissa. Aikaisempi tutkimus ei ole riittävässä määrin keskittynyt opiskelijan näkökulmaan. Innovaatioiden kehittämisen oppimiseen soveltuvien toimintajärjestelmien suunnittelulla voi olla välittömiä havaittavia vaikutuksia opiskelijan kompetenssin kehittämiseen.

Innovaatioita tarvitaan hyödyttämään liiketoimintaa, ratkaisemaan yhteiskunnan vaikeita ongelmia ja helpottamaan tavallisten ihmisten arkea. Vaikka vakiintuneita toimintamalleja rikkovan, taloudellista hyötyä tuottavan teknologisen innovaation määritelmän historia on pitkä, innovaatiot ovat tärkeitä kaikilla aloilla. Innovaatio on konkretisoitu ja implementoitu uudiste, joka tuottaa lisäarvoa. Lisäarvo on voi olla sidoksissa käyttäjän saamaan hyötyyn, mutta myös laajempaan arvon luomiseen, esim. taloudellisiin, hyvinvointia edistäviin, kestävän kehityksen tai sosiaalisiin arvoihin. Innovaatioiden kehittämiseen liittyy monialainen ammatillinen yhteistyö, sillä tarve uusille ratkaisuille kumpuaa usein monimutkaisista ongelmista. Tällaisia ongelmanratkaisuprosesseja edistää toisiaan täydentävän osaamisen hyödyntäminen.



Ensimmäinen osatutkimus oli 10 -vuoden aikana julkaistuun tieteelliseen tutkimukseen nojaava systemaattinen kirjallisuuskatsaus yksilön innovaatiokompetenssista. Tutkimus perustui hylkäyskriteerejä selvittävään kartoittavaan (scoping) kirjallisuuskatsaukseen ja aineiston kolmen tutkijan ristiinarviointiin. Toinen osatutkimus oli monialaisten innovaatioprojektien suunnittelemiseksi ja pilotoimiseksi pidettyjen opettajien kokousten videomateriaaliin perustuvan innovaatiokompetenssien oppimista tavoittelevan toimintajärjestelmän analyysi. Kolmas osatutkimus oli opiskelijan oppimiskokemusta selvittävä fenomenografinen tutkimus, joka perustui kolmen monialaisen innovaatioprojektin aikana pidettyihin päiväkirjoihin (N=74). Näiden tutkimusten aineistoja analysoitiin aineistolähtöisen sisällönanalyysin menetelmin (osatutkimukset I ja III) ja ”osista kokonaisuudeksi” -deduktiivisen sisällönanalyysin menetelmällä, joka perustui toimintajärjestelmän malliin (osatutkimus II). Tutkimuksissa sovellettiin useita erilaisia tutkimuksen johdonmukaisuutta lisääviä menetelmiä (esim. sokkona toteutettuja ristiinkatsauksia ja kolmen tutkijan vääristymäanalyysia). Tutkimuksen pääkysymykseen voitiin vastata yhdistelemällä kolmen osatutkimuksen tuloksia.

Ensimmäisen osatutkimuksen tulosten mukaan yhteistoiminnallisissa innovaation kehittämiseen tähtäävissä prosesseissa tarvitaan tiettyjä henkilökohtaisia ominaisuuksia, kuten joustavuutta, saavutusorientaatiota, motivaatiota ja sitoutumista, hyvää itsetuntoa ja itsehallintaa sekä tulevaisuusorientaatiota, luovan ajattelun taitoja, sosiaalisia taitoja, projektinhallinnantaitoja, sisältöosaamista ja valmistamisen taitoja. Toisessa osatutkimuksessa opettajien yhteiskehittelystä löydettiin jännitteitä ja ratkaisuja, jotka koskivat oppivan subjektin ja yhteisön määrittelemistä sekä tehtäviin, työtapoihin, arvioinnin menetelmiin ja työelämän haasteisiin liittyviä turnauspohjaisen monialaisen innovaatioprojektin tavoitteiden muotoilemista. Tutkimuksessa löydettiin ratkaisuja myös sääntöihin, työnjakoon ja työkaluihin, kuten prosesseihin, voittajien valitsemiseen, palkintoihin, arviointikriteereihin ja teknisiin välineisiin. Kolmannen osatutkimuksen tuloksien mukaan opiskelijat ymmärtävät oppimiskokemuksensa monialaisessa innovaatioprojektissa suhteessa ratkaistavissa oleviin konflikteihin ja epätavallisiin tilanteisiin tullessaan tietoisiksi ja lunastaessaan omaa yhteistoiminnallista toimijuuttaan ja sisäistäessään innovaatioprosessin vaiheita. Kompetenssit, jotka opiskelijat osasivat nimetä oppimistuloksiksi, liittyivät sisältöosaamiseen, erilaisten henkilökohtaisten ominaisuuksien kehittymiseen, sosiaalisiin taitoihin, kehittyviin johtamistaitoihin, luovuuteen, tulevaisuusorientaatioon, teknisiin, käsillä tekemisen ja testaamisen taitoihin sekä innovaation implementoimiseen liittyviin taitoihin, kuten tuotteistamiseen, markkinointiin, myyntiin ja yrittäjyyden suunnittelemiseen liittyviin taitoihin. Tulevaisuusorientaatio ja implementoinnin suunnitteluun liittyvät taidot näkyivät kuitenkin heikommin kuin muut muuttujat tuloksissa.

Väitöskirja esittää johtopäätöksinä osatutkimusten tuloksiin perustuvia innovaatioiden kehittämisen oppimiseen liittyviä muuttujia. Ensin, osatutkimuksiin I ja III perustuen,

yksilötason innovaatiokompetenssimuuttajat ovat henkilökohtaisia ominaisuuksia, kuten hyvä itsetunto, itsehallinta, saavutusorientaatio, motivaatio ja sitoutuminen, joustavuus ja vastuullisuus. tulevaisuusorientaatio, luovan ajattelun taidot, sosiaaliset taidot, kuten verkostoitumisen, yhteistoiminnan ja viestinnän taidot, kehittämisprojektin hallintataidot, kuten johtamisen taidot (esim. tiimin kompetenssin aktiivisen kehittämisen osaaminen, muiden rohkaisemisen ja valmentamisen osaaminen), oman ja muiden alojen sisältöosaaminen, ja konkretisoimisen ja implementoimisen suunnittelun taidot, kuten valmistamisen, tuotteistamisen, myynnin, markkinoinnin ja yrittäjyyden suunnittelun taidot.

Toiseksi, väitöskirja esittää pedagogisen innovaatioprosessin teoreettista mallia, joka sisältää useita pedagogisia kehittämisvaiheita ja arvioinnin mahdollisuuksia: orientaatio ja teoria, luovien ideoiden kehittäminen, tulevaisuusorientaatio, konseptointi, prototyyppi ja testaus sekä implementoinnin ja yrittäjyyden suunnittelun vaiheet. Malli sisältää useita arviointivaiheita. Eksplisiittisesti tai implisiittisesti fasilitoitu pedagoginen innovaatioprosessi voi edistää pidemmälle vietyjen tuotosten kehittämistä pyrkiessään implementoituihin uudisteluihin, ja se tarjoaa läpinäkyvyyttä oppimistuloksiin eri vaiheissa.

Monialaisissa innovaatioprojekteissa tärkein oppimiseen liittyvä muuttaja vaikuttaa olevan matka, ei tuotos tai onko tuotos innovaatio annetun määritelmän mukaisesti. Tunnistamalla osallistuvien opiskelijoiden vahvuuksia, heikkouksia ja osaamisen kehittämisen tarpeita on mahdollista tehdä näkyväksi toisiaan täydentävän osaamisen mahdollisuudet ja tukea yksittäisen opiskelijan oppimista osana tiimiä. Innovaatiokyvykkyyden mallia voidaan soveltaa vertaiskeskustelujen suuntaamiseen ja käytännöllisten yhteistoiminnallisen arvioinnin menetelmien kehittämiseen.

Kolmanneksi, toiseen ja kolmanteen osatutkimukseen perustuen, esitetään useita yksittäisiin osallistujiin liittyviä muuttajia opettajien tunnistamista helpottamaan silloin, kun he ohjaavat monialaisia tiimejä: Kuinka paljon opiskelijat pystyvät itsenäisesti ottamaan vastuuta ja kuinka paljon he ovat opettajan ohjaamisesta riippuvaisia, mihin opiskelijoiden motivoituminen liittyy (oppimiseen vai viihtymiseen) ja kuinka paljon konflikteja ja ristiriitaisia tilanteita opiskelijat sietävät motivaation hiipumatta.

Neljänneksi, tuloksiin perustuen suositellaan joitakin ennakkoodellytyksiä innovaatioiden kehittämisen oppimisen organisoimiseksi. Monialainen toimintajärjestelmä voi tukea innovaatio-oppimista, jos se mahdollistaa optimaalisesti konfliktien ja ristiriitatilanteiden syntymistä, opiskelijoille uusia verkostoja ja tiimejä, ja tilaisuuksia tunnistaa kompetensseja. Tiimien rakentaminen monialaisiksi mahdollistaa toisiaan täydentävän osaamisen ja oman asiantuntijuuden tunnistamista.

Kompetenssi tulee näkyväksi autenttisissa konteksteissa ja se vaatii toimintaan liittyvän intention. Intentiona voi olla avoin haaste innovaation kehittämiseksi perustuen annettuun innovaation määritelmään ja vaatimukseen mahdollistaa uuden ratkaisun kehittämisen aina sen implementoinnin suunnitteluun saakka. Työelämän avointa haastetta tarvitaan autenttisen oppimiskokemuksen ja verkostojen takaamiseksi ja eri alojen opiskelijoiden osaamisen tarpeen luomiseksi.

Monialainen tiimikokoonpano voi mahdollistaa “Minä”-ajattelun vaihtumisen “Me”-ajatteluun. Opiskelijat kuvailivat, kuinka he olivat oppineet rohkaisemaan ja valmentamaan toisiaan, tietoisesti muuttamaan asennettaan tiimin hyvinvoinnin hyväksi ja jopa tahallaan luopumaan johtajan asemastaan, jotta toiset voisivat oppia johtajuutta. Yksilöllisten erojen ja osallistujien heterogeenisuuden huomattiin johtavan positiiviseen rajojen purkamiseen yhteistoiminnassa, joka käynnistää kompetenssien kehittymistä ja innovaatioprosessin sisäistämistä. Monialaiset innovaatioprojektit ovat pedagoginen tapa yhdistää koulu yhteiskunnan toimintoihin.

Osatutkimusten tulosten perusteella opettajan rooli ei ole tehdä itseään tarpeettomaksi. Opettajien tulisi edistää innovaatioprosessin syvää ymmärtämistä, monitoroida ja helpottaa motivaatiota uhkaavaa liiallista ristiriitaa, tarjota arvioinnin työkaluja ja auttaa tunnistamaan kapeikkoja ja kehittämistarpeita yksilötason innovaatiokompetenssissa sekä edistää aktiivisesti entistä tulevaisuusorientoituneempia ja toteuttamiskelpoisempia tuotoksia, fasilitoida ratkaisun kehittämisverkostoa ja mahdollistaa siltaaminen innovaatiosta yrittäjyyden suunnittelemiseen, jos opiskelijat tällaisen mahdollisuuden löytävät. Innovaatiokompetenssimallin käyttäminen vertaisarviointikeskustelujen suuntaamisen välineenä absoluuttisen tai määrällisen oppimisen todisteen sijasta voi auttaa opiskelijoita uppoutumaan projektityön kokemukseen, mutta silti auttaa heitä havaitsemaan oppimistarpeitaan projektin alussa sekä oppimistuloksia projektin aikana ja lopussa.

Innovaatio vaikuttaa käyttökelpoiselta konseptilta koulutuksen kontekstissa silloin, kun opiskelijoiden ratkaisun lopputuloksen muotoa ei haluta määritellä etukäteen; kun opiskelijoita halutaan rohkaista luoviin ja uniikkeihin uudisteisiin ja valtuuttaa tavoitteilemaan täysiä valmiuksiaan ja jopa ylittämään ne oppimalla lisää; kun halutaan korostaa konkreettisia ja hyödyllisiä tuotoksia, kuten tuotteiden, palvelujen, prosessien tai muiden konkretisoitujen artefaktien kehittämisen tavoitetta; kun opiskelijoita kannustetaan suunnittelemaan tuotoksen implementointi (kaupallinen tai muu) ja arvoa tuottava käyttöön ottaminen; ja kun opiskelijoiden ja heidän tulevaisuuden työntajiensa ja aitojen verkostojen yhteisen autenttisen kokemuksen arvo koulurakennuksen seinien ulkopuolella ymmärretään. Innovaatiopedagogiikka vaikuttaa käyttökelpoiselta ja pätevältä termiltä sovellettavaksi silloin, kun tavoitteena on määritellä ja harjoittaa innovaatioiden kehittämistoimintaa tarkoituksellisina kulttuurisina interventioina verkottuneessa ja monialaisessa yhteistyössä, jonka tavoitteena on inhimillinen kehittyminen perustuen yhteiskunnan aitoihin arvoihin ja historiaan, ja kun tavoitteena on kehittää lisäarvoa tuottava konkretisoitu ja implementoitu uudiste.

Asiasanat: Yksilön innovaatiokompetenssi, monialaisuus, innovaatiopedagogiikka, toimintajärjestelmä, oppimiskokemus, pedagoginen innovaatioprosessi, korkeakoulutus, ammattikorkeakoulu

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Laura-Maija Hero

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# Table of contents

Abstract	4
Tiivistelmä	8
Acknowledgements	12
Table of contents	14
Tables and figures	16
List of original publications	17
1. Introduction	18
2. Theoretical premises for learning to develop innovations	25
2.1 Innovation is a novelty made concrete and implemented to convey value	25
2.2 Innovation development processes	27
2.3 Innovation development as a networked and multidisciplinary activity system	28
2.4 Competence needed in innovation development	31
2.5 Learning as an authentic experience and practical activity	36
2.6 Learning to develop innovations as part of formal education	39
2.7 The theoretical framework at a glance	44
3. Aims and research questions	47
4. Short overview of the sub-studies	51
5. Methods	54
5.1 Research process and methodology	54
5.2 Material collection	60
5.3 Analysis methods and processes	63
5.4 Methods to advance rigor and ethical research conduct	65
6. Findings from the sub-studies	68
6.1 Sub-study I: Individual innovation competence	68
6.2 Sub-study II: A multidisciplinary innovation project as a pedagogical activity system	70
6.3 Sub-study III: Learning experience in multidisciplinary innovation projects	74

7. Discussion and conclusions	77
7.1 Competence factors	77
7.2 Factors related to assessment	81
7.3 Factors related to the pedagogical process	83
7.4 Factors related to organising the activity and the teacher's role	85
7.5 Why is the concept of innovation useful in education?	90
7.6 Methodological considerations and limitations	92
7.7 Theoretical considerations and practical implications	95
7.8 Future research	99
References	102
Original publications	127

# Tables and figures

Table 1. Aims of the dissertation	49
Table 2. Methods, materials, participants and analysis methods of the sub-studies in relation to their research questions (sub-studies I–III)	55
Table 3. Research process and timing	56
Table 4. Individual innovation competences based on academic research published 2006–2015 (Hero et al., 2017)	69
Table 5. Students' learning experience in a multidisciplinary innovation project (Hero & Lindfors, in press)	74
Figure 1. A theoretical framework for studying learning to develop innovations	44
Figure 2. Perspectives to study learning to develop innovations (delimitations)	48
Figure 3. Innovation tournament activity system (Hero, 2017; adapted from Engeström, 1987, 2014)	72
Figure 4. Individual innovation competence, IIC (Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press)	80
Figure 5. A pedagogical innovation process, PIP (Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press)	84
Figure 6. In addition to competence factors, several pedagogical factors are crucial for teachers to recognise while facilitating learning to develop innovations in multidisciplinary teams (Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press)	89

# List of original publications

## Sub-study I

Hero, L.-M., Lindfors, E., & Taatila, V. (2017). Individual innovation competence: A systematic review and future research agenda. *International Journal of Higher Education*, 6(5), 103–121. doi:10.5430/ijhe.v6n5p103

Sub-study I was planned, studied, managed and written by the first author. In the analysis process, the final research material was subjected to a three-author blind bias assessment, where the second and third authors participated. The co-authors contributed to the manuscript by commenting.

## Sub-study II

Hero, L.-M. (2017). Innovation tournament as an activity system to promote the development of innovation competence. *Journal of Professional and Vocational Education*, 19(4), 8–31.

Sub-study II was planned, studied, managed and written by the first author.

## Sub-study III

Hero, L.-M., & Lindfors, E. (in press). Students' learning experience in a multidisciplinary innovation project. *Education + Training*. doi:10.1108/ET-06-2018-0138

Sub-study III was planned, studied, managed and written by the first author. The second author participated in a blind cross-review of 15% of the material and probed the initial categorisation to guard against subjectivity bias. The second author contributed to the manuscript by commenting.

# 1. Introduction

This dissertation focuses on how to learn to develop innovations. Innovations are needed to benefit business, solve difficult problems faced by society and to ease the everyday lives of ordinary people. The European Commission has recognised an innovation gap: Higher education institutions are not contributing as much as they should to innovation in the wider economy. The performance varies strongly between European Union regions (European Commission, 2017). Learning for innovation is thus a central element in European policymaking regarding developing education (European Commission, 2012; OECD, 2004, 2008; Tether, Mina, Consoli, & Gagliardi, 2005; Toner, 2011). The European Commission (2012) has also called for new partnerships to improve open innovation and multidisciplinary knowledge-sharing for the rapid prototyping of new products, services, processes, structures and systems, and it emphasises the development of “innovation skills” (European Commission, 2017).

Higher education has a crucial mandate to participate in the functions of society and to collaborate on the areal and regional levels to provide a workforce capable of innovation collaboration. Higher education has achieved this with varying success rates and thus further research is suggested (Badcock, Pattinson, & Harris, 2010; Tynjälä, 1999; Vila, Pérez, & Morillas, 2012). Diversity and mobility between education and work present a paramount challenge that needs better conceptualisation in educational theory (Akkerman & Bakker, 2011). There has also been a call for more focused research on networked practitioner-based approaches outside the domain of classroom education that encompasses experiential learning but also moves towards more of a micro-exposition of the general view that we learn by doing (Rae, 2010; see Dewey, 1916/1985). A lack of research in the area of innovation education and innovation education programs has been noted especially in the domain of higher education and vocational education and training (Canen & Canen, 2002; Järvi, 2012; Maritz et al., 2014). For example, Miettinen and Lehenkari (2016) have emphasised the importance of studying and developing emerging new institutional arrangements in higher education to enhance creative encounters for innovations and to bring the problems of firms, service providers and public organisations and the expertise of teachers and students from different disciplines together to find solutions and to initiate development projects.

Learning during innovation processes has been studied extensively in the organisational context, as innovation processes have often been defined as learning processes *an sich*.



(e.g. Dodgson, 1991, 1996; Engeström, 1999; Fenwick, 2003; Harkema, 2003; Hasu, 2001; Lundvall, 1988, 1992; Saari & Kallio, 2011; Sandberg & Ohman, 2011; von Hippel, 1994, 1998; von Hippel & Tyre, 1995, 1996). High expectations are being placed on the cooperation and networking between individual people, employees, entrepreneurs and even students as sources of innovation (Hasu, Honkaniemi, Saari, Mattelmäki, & Koponen, 2014; Høyrup, Bonnafous-Boucher, Hasse, Lotz, & Moller, 2012; Kesting & Ulhøi, 2010; Miettinen, 2013; von Hippel, 1998). Individual developers' perspectives on innovation have been found to be underrepresented in the research (Peschl, Bottaro, Hartner-Tiefenthaler, & Rötzer, 2014; Standing et al., 2016).

The strategic nature of education in terms of innovation competence has been largely ignored (Vila et al., 2012). Furthermore, according to Maritz et al. (2014), very little empirical research exists on the development and assessment of innovation education programs. However, young people are expected to be prepared to collaborate in solving future problems and producing innovations in areas that presently do not exist (Sawyer, 2006a, 2012, 2014; Zang, Hong, Scardamalia, Teo, & Morley, 2011). It is the task of education to equip people with suitable competences. Educational institutions need to build an outward-looking culture of innovation and entrepreneurship with activities based around real-world problems. The collaboration between higher education and working life is increasingly perceived as a vehicle to drive the mission (Ankrah & Al-Tabbaa, 2015; Rantala & Ukko, 2018). In the context of professional education, this calls for novel types of networked and systemic collaboration entities; namely, activity systems (Engeström, 1987) for learning. Given this, collaborative projects should become a mandatory part of curricula in all fields of education (see e.g. Taatila & Raij, 2012).

In educational sciences, there are at least four larger lines of research focusing on innovation-related learning. The first one is the research focusing on innovative knowledge communities in expert organisations (e.g. Engeström, 1999; Hakkarainen et al., 2004; Nonaka & Takeuchi, 1995; Paavola et al., 2004). The other one is employee-driven innovation that aims, for example, to unfold the organisational learning that springs from employee participation (e.g. Ellström, 2010; Haapasaari, Engeström, & Kerosuo, 2017; Hasu et al., 2014; Høyrup, 2010; Lehenkari, 2006). The third line of research that can be mentioned is university–industry innovation collaboration that focuses on research and development (R&D) networks, and that has mainly studied the benefits and networks of industry, rather than individual students and learning, and is understood as the role of the university mostly being as a partner responsible for research (Ankrah & Al-Tabbaa, 2015; Mäkimattila, Junell, & Rantala, 2015; Rantala & Ukko, 2018; Slotte & Tynjälä, 2003). All these lines of research aim at unfolding the sources of innovation as a collaborative and organisational construct. The most recent developments in higher education have focused mainly on developing competence measuring tools (e.g. Keinänen & Oksanen, 2017; Keinänen, Ursin, & Nissinen, 2018; Marin-Garcia, Pérez-Peñalver, & Watts, 2013). Qualitative studies from the perspective of educational institutions facilitating innovation to aid learning to develop innovations

and the individual students' learning perspective are mostly missing. This line of research seems to still be in its infancy. For example, Kars-Unluoglu (2016) postulates that innovation is a perfect example of a rapidly developing interdisciplinary field of education that is growing in diverse directions. It is a field covering issues from open problems and opportunity identification, to design, to commercialisation, and hence it calls for competences, techniques and ways of collaborating. Innovation development is often associated with teams of diverse individuals and multi-professional collaborations (Nandan & London, 2013; Sloep, Berlanga, & Retalis, 2014; Van Der Vegt & Bunderson, 2005). The motivation for such organisation often springs from the need to solve complex problems that benefit from diverse perspectives (Jonassen, Strobel, & Lee, 2006; Kurtzberg, 2005; Van der Vegt & Janssen, 2003). It benefits from a real cause, challenge or problem, understood both as something that gives rise to a call for action and with which people from diverse backgrounds and expertise wish to participate in working for. In the educational context, innovation has been defined as artefacts resulting from a cognitive and social process of collectively creating new knowledge that is brought into reality as concrete, novel solutions that are accepted in their usage to convey value (see Peschl et al., 2014; Sawyer, 2006b; 2009). They can take such forms as new services, products, processes, marketing and organisational innovations (Oslo Manual, 2005).

### *Research aim*

Theoretical advancements and empirical research findings have emphasised the social and collaborative nature of innovation development. However, research related to innovation development has mainly focused on organisational aspects, even in university-related contexts. Based on the theoretical considerations presented in this dissertation, the focus should shift towards learning outcomes, activity system design and student learning experiences to be able to unfold the phenomenon of learning to develop innovations within educational contexts. It can be argued that the concept of innovation can be quite usable in project-based learning and students' development work in terms of their working life when describing the best possible and most desirable project outcomes. If the project outcome is not an innovation by definition, can learning still occur? In the context of higher education, this calls for a thorough understanding of (1) innovation competence, (2) novel types of networked and multidisciplinary activity systems for learning by opening up the school walls to society, and (3) students' learning experiences in these activity systems.

The aim of this study was to determine the relevant factors for learning to develop innovations in collaboration between working life and educational institutions. Without understanding the required competences, it is difficult to facilitate pedagogical innovation processes (see term used in comprehensive school context Lepistö & Lindfors, 2015) offering a platform for this type of learning. Designing the right types of activity systems to facilitate innovation learning (Bruton, 2011; Lindfors & Hilmola,

2016; Sawyer, 2014) can have immediate, observable effects on competence development (Amabile, 1996; Pant, 2012).

This study examined learning to develop innovations in the context of universities of applied sciences in Finland. It looked for the factors relevant in learning to develop innovations in collaboration between education and working life. The relevant factors were delimited to those variables that would be needed in curriculum development and pedagogical design: learning outcomes, learning design and learning experience. Therefore, it aimed at unfolding this phenomenon to aid curriculum development and the pedagogical design of authentic learning opportunities supporting this aim. First, individual innovation competence was defined to understand what kind of competence support the development of innovations (sub-study I, i.e. Hero, Lindfors, & Taatila, 2017). Sub-study II investigated the development of a suitable activity system (sub-study II, i.e. Hero, 2017). Next, sub-study III investigated the student learning experience in university–industry collaboration during an authentic development activity aiming at an innovation, as defined in this study (sub-study III, i.e. Hero & Lindfors, in press). In this general part of the dissertation, the theoretical premises that preceded the sub-study design are structured based on previous research on innovation development and learning as a real-world experience, the research process is made transparent, the findings of the sub-studies are summarised and the findings are discussed to answer the main research question. It is important to understand how innovations in organisations and their networks are born. It is also important to understand the concept of learning as it was understood during the design of the empirical research phases. Finally, the findings are discussed and conclusions made with theoretical and practical implications for higher education institutions, curriculum designers and teachers interested in facilitating these types of activities. Some limitations and future research opportunities are presented.

This information is likely important for curriculum design and teachers at different educational levels in setting aims and objectives, as well as planning pedagogical processes and individualised assessments. It is the task of education to equip people with suitable competences and learning experiences.

### *Contexts of the sub-studies*

Sub-study I was a systematic review that collected 10 years of research article material on individual innovation competences. These scientific articles reported on research conducted in both organisational and educational contexts (see appendix 1, sub-study I). The final sample represented research in multiple research fields. Ten of the studies were conducted in an educational context (higher education, secondary education), while 14 were conducted in an organisational context (organisational psychology, human resource management or business studies) and four studies occurred in both contexts (educational and organisational).

The context of sub-studies II and III was professional higher education (i.e. tertiary-level professional education in Finland). The Finnish higher education system comprises universities and universities of applied sciences. The universities of applied sciences (UAS) are multi-field institutions of professional higher education that engage in applied research and development. (Finnish National Agency for Education [EDUFI], 2019). They are on level 6–7 in the International Standard Classification of Education (ISCED) system. A bachelor's degree takes 3.5–4.5 years of full-time study (Finnish National Agency for Education [EDUFI, 2012; Ministry of Education and Culture [MEC], n.d.). Sub-studies II and III were conducted according to the **MINNO® Innovation project 10 European credit transfer system (ECTS)** Metropolia UAS curriculum that is today implemented in every bachelor students' curricula (Curricula, 2018). Metropolia UAS is Finland's largest UAS that educates in the fields of culture, business, health care and social services and technology, with over 16,000 students and 67 degree programs. Every undergraduate takes part in a *10 ECTS* innovation project. The *MINNO® Innovation project* pedagogical program is a multidisciplinary innovation project conducted via an education–work collaboration based on the *Innovation project 10 ECTS* curriculum. At the Metropolia UAS, every student completing a bachelor's degree participates in this mandatory second- or third-year project worth ten ECTS credits, equivalent to approximately 270 hours of study time. The course is mandatory for all students because, in the university's view, innovation is important in all professional fields. For example, social problems need innovative solutions that produce considerable value in terms of health, wellbeing, culture etc. (Metropolia UAS, 2018). The project's explicit aim for the students in the context of this study was to build novel solutions, products, services or processes to resolve the open challenges presented by companies and other work organisations. The duration of the project courses investigated in this study ranged from 7 to 14 weeks. The course outlines in the faculties concerning this study were similar for each semester, and only varied slightly depending on the participating teachers. The project course design placed special emphasis on multidisciplinary collaboration, which was supported by facilitators from the university and was commissioned by a work organisation as a customer for student teams. At the centre of the activity (see sub-study III, figure 2) was a real-world problem or opportunity from working life; the goal was to produce a novel solution to the problem (for a more complete description, see Hero, 2017; Hero & Lindfors, in press; Rautkorpi & Hero, 2017). Sub-studies II and III were related to this project course curriculum descriptions and its five (5) individual course implementations. Sub-study II was related to two project course implementations that were part of TeenMINNO -project (spring and autumn 2017, see table 3). TeenMINNO was funded by European Social Fund (ESF) during 2016-2018 ([www.metropolia.fi/teiniminno](http://www.metropolia.fi/teiniminno)). Sub-study III was related to three project course implementations (spring and autumn 2015 and autumn 2016, see table 3.).

Sub-study II was conducted in the same curricular context. The material was collected through a pedagogical variation of this project course in a collaborative innovation project mixing students and teachers from one UAS and one secondary VET (vocational

education and training) institution in Finland to ensure high levels of heterogeneity in the project teams. Omnia, the Joint Authority of Education in Finland, is a multi-sector vocational educational institution with appr. 8,000 students studying for vocational qualifications. Most of the VET students participated via Open UAS, and were thus enrolled as UAS students. The study focused on the joint planning activity of a new type of pedagogical design based on the competence findings from sub-study I. A gamified activity system was designed over one academic year. The planning forum consisted of 17 teacher team members from different disciplines. The members represented the cultural management, business, entrepreneurship, digital communications, textile design, social and service design study fields. The members of the team developed and twice piloted a pedagogical tournament model based on innovation competence research (sub-study I). Historically, innovation tournaments are a specialised goal-oriented form of idea competition outside formal education and its permanent institutions. Through a series of carefully designed stages, innovation tournaments aim at generating and collecting valuable ideas, as well identifying potentially commercialisable innovation opportunities (Terwiesch & Xu, 2008). A tournament can facilitate networked innovation processes (Duverger & Hassan, 2007; Kay, 2011; Morgan & Wang, 2010; Pedersen et al., 2013), aid in managing them (Adamczyk, Bullinger, & Möslin, 2012; Boudreau, Lacetera, & Lakhani, 2011; Malhotra & Majchrzak, 2014) and benefit social processes (e.g. Füller, 2006). In innovation tournaments, individual participants form teams, and the ideas and solutions of the individual people in the team potentially lead to valuable innovation opportunities for the involved organisations recruited by the tournament organiser (Passaro, Quinto, & Thomas, 2017). As a part of the higher education curricula, innovation tournament activities are seldom used for project-based learning to facilitate pre-defined competence development. In sub-study II, they were considered as a potential way to organise networked innovation development cooperation between different grades of vocational institutions, society and local companies, and were thus piloted.

The material for sub-study III was collected from the same project course from 2015–2016 (*Innovation project 10 ECTS*, as described above) during three different course implementations. The participating students were UAS students from the culture, wellbeing, health and technology subject areas. Open challenges as tasks for the projects came from companies, public organisations, development projects, associations or foundations and a social media community. Most of the open tasks concerned social problems. The project outcome was not determined in advance. During the 1.5 years of this study, 50 open tasks were given by various organisations (e.g. The city for babies? How to maintain wellbeing in the forest industry. How can we prevent ordinary immigrants from becoming radicalised? New services for a yoga studio, new simulations for first aid services – how can we reduce the loneliness of the youth? New gaming solutions for a children's hospital).

The students were divided into multidisciplinary teams that were as heterogeneous as possible, according to the students' study disciplines and choice of project. The process included orientation and theory, customer presentations and students choosing a project, team project work, a final public event and delivery to the customer. Teams were tutored for 1–2 days a week, and the customers gave feedback on the solutions approximately 2–5 times. Typically, a team's project outcome included a preliminary prototype with a planned implementation. The outcomes varied from motion-sensor health-game prototypes and new types of documentary series, to tested event models involving volunteer staff, etc. Some outcomes were productisation manuals with, for example, a depicted production network and branding outline to help the customer implement the solution afterwards. Some of these novel solutions were commercialised and a couple of start-up companies emerged later.

## 2. Theoretical premises for learning to develop innovations

In order to understand how learning to develop innovations is considered in this study, the characteristics of innovation development and learning are first discussed. As both of these theoretical aspects are vast and involve many theories and much research, some limitations must first be acknowledged. The introduction to innovation development is delimited to those aspects that are relevant in this context; namely, innovation as a concrete artefact and as an outcome from the practical collaborative activity of people. In terms of learning, the introduction to the philosophical grounds is delimited to philosophical background that have directed the planning of the sub-studies and affected the context and course design; namely, learning as an authentic and practical experience as defined by John Dewey. These aspects are relevant to understand when aiming at education that promotes learning to develop innovations in the defined context as the practitioners (teachers and curriculum developers) often have professional background in their respective fields. However, in other contexts or to reach other aims there may be other relevant aspects and perspectives.

An overwhelming amount of the available literature and research concerning the definition of innovation exists within innovation management, but also in many other fields of research. In this context, it is important to understand the concept of innovation as a practical, concrete and useful concept that helps in describing the phenomenon of developing innovations as the activity of people. Therefore, I do not give much space herein to go through all the possible definitions but delimit by pointing out the characteristics of the concept that are important to take into account in this limited context and that are thus used to formulate the conceptual definition for this study. This formulation was the starting point during the planning phase of this dissertation project and was the basis for the three sub-studies.

### 2.1 Innovation is a novelty made concrete and implemented to convey value

Innovations are often approached by using closely connected concepts as tools to understand the nature of the concept. The definition of innovation is usually separated from mere creativity, although they are partially overlapping concepts. Amabile (1996)

identified innovation as the successful *implementation* of creative ideas. According to Alves, Marques, Saur and Marques (2007), creativity is linked to idea generation, while innovation implies the transformation of *ideas into new products or services*. In this sense, innovation is the implementation of creativity results. Novelty is an essence of the definition of innovation (Greve & Taylor, 2000; Gupta, Tesluk & Taylor, 2007). More specifically, an innovation includes the elements of relative rather than absolute *novelty*, but also *intentional benefit* to individuals, groups, organisations, or wider society, and the application or implementation of the creative idea: "The intentional introduction and application within a role, group, or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, organization or wider society." (West and Farr, 1990, p. 9) Abernathy and Clark (1985) postulate that innovation is concerned with the initial market introduction of a new product, process, or other solution that either disrupts or entrenches existing competences. Quintane et al., 2011 has introduced a definition that understands innovation as the creation of new duplicable knowledge, considered new in the context and demonstrated *useful* in practice. Innovations are not only technical novelties and most of the definitions collated and compared in recent literature reviews do not include technology as a criteria (e.g. Quintane et al., 2011). In the educational context, Peschl et al. (2014) and Sawyer (2006b; 2009) have identified innovations as artefacts resulting from a cognitive and social process of collectively creating new knowledge that is brought into reality as concrete, novel solutions that are accepted in their usage to convey value. They can take such forms as new services, products, processes, marketing or organisational innovations (Oslo Manual, 2005). To conclude, innovations can be any kind of novel product, process, service or other type of outcome, but not only ideas or inventions. The definitions have included criteria such as "new", "useful", "a concrete thing" and "implemented" (for more complete evaluation of definitions, see Baregheh, Rowley, & Sambrook, 2009; Eveleens, 2010; Quintane et al., 2011). **In this study, an innovation is a novelty that is made concrete, useful and implemented to convey value** (mainly following Peschl et al., 2014; Sawyer, 2006b; 2009; West and Farr, 1990; Quintane et al. 2011).

In educational contexts, it may be unnecessary to strive primarily for radical innovations (cf. Schumpeter, 1942; Veryzer, 1998) to promote learning, as learning happens during the real development experience. Yet, the degree of novelty of an innovation is not intrinsic to the idea; it is linked to the individuals judging that novelty. In the literature, the individuals that constitute the context into which an innovation is introduced are assumed to judge its novelty (Damanpour, 1991; West, 2002; West and Farr, 1990). However, an innovation can be new to a specific context but not to the rest of the world. According to Van de Ven (1986, p. 2), as "long as the idea is perceived as new to the people involved, it is an 'innovation', even though it may appear to others to be an imitation or something that exists elsewhere". In higher education praxis, the concept of innovation as an outcome of students' work can be usable in project-based learning when



describing the desired and most original project outcomes such as novel products or services that are not only ideas, but solutions taken or planned to be taken into use and that also convey value outside educational institutions. Although there is a long history of innovation defined as disrupting technological novelties with a business benefit (see e.g. Godin, 2016, 2017), innovations are important in all professional fields. The value they create is tied to novelty values and to the benefit for the user groups, but it can also be tied to more widespread value categories (e.g. economic, wellbeing, sustainability, or social). For example, social innovations (Moulaert, MacCallum, Mehmood, & Hamdouch, 2013; Mulgan, 2012; Murray, Caulier-Grice, & Mulgan, 2010; Nicholls & Murdock, 2012) would primarily be oriented to generating social rather than economic value.

## 2.2 Innovation development processes

To understand the nature of an innovation as a concrete and useful artefact, it is meaningful to understand it also as an outcome of a process. Innovation is seen as an outcome of a process whereby collaboratively-created ideas are transformed into a single product, service or other end result, often through interactions with several stakeholders (Baregheh et al., 2009; Peschl et al. 2014; Sawyer, 2006b). Organisations and formal or informal networks (see Pittaway et al., 2004; Shaw, 1993) undertake the innovation journey (Cheng & Van de Ven, 1996) when they invent, develop and implement new products, programs, services, or other new concrete solutions. Depending on the scope, this journey can vary greatly in the number, duration and complexity of events that unfold along the way. According to Cheng and Van de Ven (1996), whatever its scope, this journey is an exploration into the unknown by which novelty emerges.

There are many perspectives on the stages of the process. Empirical findings of studies unfolding innovation processes have found that the process involves both orderly periodic stages, uncertainty, random sequences and chaotic patterns (Cheng & Van de Ven, 1996). The overall development process has been divided into three more general stages: (1) the fuzzy front end, (2) new product development, and (3) commercialisation or other implementation into use. The fuzzy front end comprises creative activities that are often chaotic, unpredictable and unstructured, and that come before structured development processes (Alves et al., 2007; Koen, 2004). The basic “sources of innovation” (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004, p. 111) have been defined, for example, as tacit knowledge and its explication for communal use (Nonaka & Takeuchi, 1995), overcoming tensions, contradictions and ambiguities for something that is not there yet by questioning the existing practices (Engeström, 1987, 1999, 2016) and working deliberately to create and extend knowledge objects (Bereiter, 2002). However, these interpretations seem to describe the fuzzy first phases and the change happening in practical actions: Creativity is only one part of the innovation process (Alves et al., 2007; Baregheh et al., 2009). Alves et al. (2007) argue that creativity, innovation and new

product development are intimately correlated. Future opportunity (Tidd, Bessant, & Pavitt, 2001), and, for example, concretising, developing and implementing, are likely important. Idea phases require more creative and free methods, but it soon becomes necessary to subject the ideas to stricter development methodologies while developing the product towards concrete implementation in a product development process (Cooper, 2001; Kahn, 2004). A literature review of innovation process models and their implications (Eveleens, 2010) summarised that the models had the same kinds of phases with some order in them. The main phases were idea generation, selection, developing and prototyping, implementing/launch, post-launch and learning/evaluation. The process has also been identified as involving rapid prototyping and testing, manufacturing (making) and implementing the product or service (Baregheh et al., 2009). In this dissertation, an innovation process is not only understood as the first idea development phase, but as a larger and more complete process from future opportunity recognition and idea development, to product or service development, and to implementation.

## 2.3 Innovation development as a networked and multi-disciplinary activity

Innovation processes are often understood as knowledge creation through collaborative expertise and development between rather than within people (see e.g. Paavola, Lipponen, & Hakkarainen, 2004). They are rooted in systemic features of a larger community and individuals acting as a part of a stream of social activities in an innovative knowledge community (Paavola et al., 2004). Exemplary innovation processes are often associated with groups that bring together highly diverse and talented individuals to form a new development collaboration. For individuals, even experts, this involves a continuous effort of going beyond the current level of accomplishment and working at the edge of one's competence to adapt to the progressively changing requirements of the environment (Hakkarainen et al., 2004). Innovations can originate from organisations, but also from looser and more informal networks (Conway, 1995; Pittaway, Robertson, Munir, Denyer, & Neely, 2004; Shaw, 1993). These networks may involve also educational institutions (e.g. Rantala & Ukko, 2018). According to Pittaway et al. (2004), particularly complex and radical innovation processes, benefit from engagement with a diverse range of partners, which allows for the integration of different knowledge bases, behaviours and ways of thinking.

### *Multidisciplinary activity systems*

Professional multidisciplinary collaboration is related to the development of innovations, as the need for new solutions springs from complex problems in societies or from the underlying needs of people (Nandan & London, 2013; Sloep et al., 2014; Somech, 2006; Van Der Vegt & Bunderson, 2005). Complex problems benefit from diverse perspectives and cannot be solved by a single individual, authority or company (Jonassen

et al., 2006; Kurtzberg, 2005; Van der Vegt & Janssen, 2003). They benefit from boundary-crossing between different activity systems (Konkola, Tuomi-Gröhn, Lambert, & Ludvigsen, 2007; Tuomi-Gröhn & Engeström, 2003). By definition, as applied in this study, **multidisciplinarity refers to professional heterogeneity, which is the extent to which a team consists of members from different educational or professional specialisations (see e.g. Shin & Zhou, 2007).** Pittaway et al. (2004) also found that one of the principal benefits of networking when developing innovations is the pooling of complementary skills. **The complementarity of knowledge** (Miettinen & Lehenkari, 2016) of participating experts and representatives from different fields promotes the success of the development activity. **An activity system** is a collective formation of a complex mediational structure that serves as the primary unit of analysis in cultural-historical activity theory. An activity system is the engagement of individuals towards a certain goal or objective (Engeström, 1987). It involves a subject, a community, an object, tools, rules and the division of labour used in the activity, and the actions and operations that affect the outcome (Nardi, 1996). The subject of the pedagogical activity system is the individual or groups of individuals involved in the activity. The community is the social group that the subject belongs to while engaged in the activity. The tools include social others and the artefacts that can act as resources for the subject in the activity. The rules are any formal or informal regulations that can, to varying degrees, affect how the activity takes place. The division of labour refers to how the tasks are shared among the community. The outcome of the activity system is the end result of the activity (Engeström, 1987; see also Jonassen & Rohrer-Murphy, 1999). Finally, the object of the activity is the physical or mental product that is sought. It represents the intention that motivates the activity. Some examples of the multidisciplinary innovation development activities from the field of educational research are in order. First, an innovation process solving a problem related to the healthcare of homeless people involved healthcare, the city authority, social work, welfare and volunteers, and led to the “SBS” (side-by-side) model, which involved multidisciplinary, cross-sector teams working to ensure that homeless patients were cared for in a holistic way and discharged into an appropriate environment (Fuller, Halford, Lyle, Taylor, & Teglberg, 2018). Fuller et al. (2018) found that an underpinning cause provided an essential appeal to participants with different roles from diverse occupational and disciplinary backgrounds and thus provided a goal-oriented intention for innovation that originated from learning in this community. Second, Miettinen, Lehenkari and Tuunainen (2008) found that a successful innovation process in a medium-sized company developing a ground-breaking new solution for the biotechnical industry required networked collaboration, as well as the acquisition of new competences and learning during the collaboration, and these evolved simultaneously and interactively. Third, a research project followed the development of a ground-breaking new functional food-product family called “Benecol” that was found to lower the level of cholesterol in human blood. Various completely different types of professional resources and expertise were mobilised and combined to create the product.

The collaborative network was based on trust and reciprocity. The case of “Benecol” suggested that innovation development was a distributed but collaborative activity system of developers from different disciplines and industries consisting of, for example, medical experts, pulp and paper engineers, experts in vegetable oils and experts in commercialisation. No single inventor could be denominated (Lehenkari, 2000; Miettinen & Lehenkari, 2016). Fourth, an example from an educational institution and the dorms situated nearby, but far from the faculty classrooms, is “Facebook,” which originated from the persistent development work and self-supported learning of graduate students and from their abilities to collaborate and build networks (Carlson, 2010).

Professionally diverse teams provide a wider variety of knowledge resources and perspectives (Harrison, Price, Gavin, & Florey, 2002; Kearney & Gebert, 2009; Shin & Zhou, 2007; Van der Vegt & Bunderson, 2005). Reuveni and Vashdi (2015) suggested that the relationship between the extent of professional heterogeneity and innovations as outcomes may be explained, at least partially, by the ability of team members from different disciplines and areas of education to develop a common cognitive structure regarding their mission and the way in which it should be achieved. They found that as the extent of multidisciplinary grows in innovation development teams, teams are likely to be more innovative, as the diversity encourages team members to speak up, elaborate information and get to know one another. This increases the likelihood that the team will come up with feasible and tangible ways of putting the ideas into practice. When multidisciplinary is high, team members must increase the efforts they invest in getting to know each other’s perspectives, skills, abilities and knowledge (Phillips & Loyd, 2006; van Knippenberg, de Dreu, & Homan, 2004). In highly multidisciplinary teams geared towards innovation, team members are aware that they are beneficial to the team on the basis of the uniqueness of their expertise.

#### *Multidisciplinary: Benefits and tensions*

The multidisciplinary of the collaboration seems to be of benefit in many phases of innovation processes. Multidisciplinary and multisectoral cooperative environments reinforce creative competences and allow for rich combinations of otherwise disconnected pools of ideas, even more radical ideas and solutions adjusted to complex problems (Alves et al., 2007; Hargadon, 2003). According to Reuveni and Vashdi (2015), multidisciplinary enhances the need for generating a shared understanding of how the team will cooperate and dynamically adjust to actually implement the innovative idea. In the ideas’ selection phase, they perceived the need to let rational methods coexist with intuitive decision processes. In the product development phase, they noticed that the diverse mindsets, attitudes and skills in the network contribute greatly to its flexible problem-solving capacities. Diversity seems to make a contribution not only to creativity phases and development work, but also to the implementation, for example, in the commercialisation phases of innovation development, by offering wide beneficial networks (Aarikka-Stenroos, Sandberg, & Lehtimäki, 2014).

As a down side, multidisciplinary teams also hold the threat of a great deal of difficulty (Derry, Schunn, & Gernsbacher, 2005). While professional heterogeneity enlarges the variety of knowledge, perspectives and experience, the diverse professional backgrounds and different terminology of the team members may cause tension, which may badly influence communication, collaboration and team integration (Ancona & Caldwell, 1992; Harrison et al., 2002; Keller, 2001). As a result, they may hold on to their own perspectives regarding the task and not attempt to adjust their views to a more shared construct. However, it seems that the same team members understand that while they are highly diverse and hold different expertise and perceptions, they will need to adjust their perceptions of how the team processes should unfold to a more shared construct. This can lead to collaborative learning opportunities. Multidisciplinary collaboration during innovation processes can grow members' competitive competence, provided the collaboration exhibits diversity, coherence and complementarity (Alves et al., 2007).

To conclude, in many innovation process studies, the activity involved in developing an innovation is ultimately found to be a collaborative learning process *an sich*, as multidisciplinary activity systems (Engeström, 1987) offer opportunities for new knowledge creation and force constant competency development when faced with the never-experienced-before situations (Hasu, 2001; see also Engeström, 2016). In higher education, this learning opportunity has been noted. Multi-professional programs are examples of learning experiences that promote cross-disciplinary teamwork (Schmidt et al., 2003; Seat & Lord, 2003; Shuman, Besterfield-Sacre, & McGourty, 2005). According to Nandan and London (2013), multi-professional educational experiences can enable students to engage in learning which can later facilitate the creation of innovative solutions. According to Schaffer, Lei, Reyes, Oakes and Zoltowski (2008), cross-disciplinary team learning for solving real-world problems and creating new knowledge requires collaborative working groups or teams that are actively working on a problem. Multidisciplinary teams bring together the knowledge of various persons with different skills to develop new solutions and develop new competences while doing so.

## 2.4 Competence needed in innovation development

The competence needed to develop innovations has been defined in academic research in many different ways and in many contexts. This hampers the understanding of the concept and makes it hard to find research concerning it. Those definitions that emphasise individual competences are hard to recognise as the key words are often the same even though the meaning is totally different.

*Excluding definitions to understand the concept*

To be able to define innovation competence as a concept to be used in the context of learning to develop innovations, it is important to exclude the definitions expressed by the same terms first. There are several confusing definitions that cannot be mixed with

each other. There are several fields of research that focus on innovation competence from different perspectives. Therefore, it is impossible to search by research area and the focus should first be on definitions of different contexts. The term “innovation competence” is used, for example, as an *organisation-level innovation capability or innovation competence* that refers to the competence of an organisation, industry, firm, or product program. Organisational capabilities that enhance and support the production of innovations are those such as, for example, the absorptive capacity of a company or enterprise, knowledge creation within departments, teams or other organisational entities, linkages to other companies, production process efficiency, economic investment capability and R&D spending capabilities (e.g. Kodama & Shibata, 2014; Menguc, Auh, & Yannopoulos, 2014; Wang, 2014; Yang, 2012). The term has also been used as a *country-, region- and area-level innovation capability or competence*. The region-, country- or area-level innovation competence is measured, for example, by the number of enterprises producing technological innovations, policies supporting innovation, or produced end-products (Apiakun, 2011; Chen et al., 2009; DiPietro, 2009; Golejewska, 2013). *Innovativeness of a non-human thing* (e.g. Akgün & Keskin, 2014; Barone & Jewell, 2014; Chiang & Hung, 2014; Ihn, 2012) is a quality of a non-human entity; the innovativeness of a policy, product, place, brand, food, service, software, web site, system, technology, fashion, design process, or of marketing deliverables. For example, teaching innovations (Lim, Moriarty, & Huthwaite, 2011) are understood as certain ways of teaching – an innovative teaching practice – that can consist of a specific new pedagogy, tasks for students, learning context etc. The innovation competence of an individual is not in focus, but the innovativeness of a non-human, still human-made, innovative product or practice is. In these studies, the key words resemble those in individual-level innovation competence studies such as innovativeness.

Individual-level innovativeness as *consumer innovativeness* is defined as the ability for the diffusion or adoption of novel products or technology goods. In this marketing, communication, or consumer studies context, individual-level innovativeness is often defined as the ability to *adopt* innovations (e.g. Merchant, Rose, & Rose, 2014; Noh, Runyan, & Mosier, 2014). The diffusion of innovations is a theory that seeks to explain how, why and at what rate new ideas and technology spread through cultures and how new technology is adopted. The categories of adopters are innovators, early adopters, the early majority, late majority and laggards (Rogers, 1962/2003). “Individual” in this context is then the consumer who is consuming new technology or other new things. There are many tools to measure innovativeness as a willingness to try or adopt new things, for example, the Jackson Personality Inventory, Kirton Adaption–Innovation Inventory (KAI) and the Individual Innovativeness Scale (e.g. Hurt, Joseph, & Cook, 1977; Jackson, 1976; Kirton, 1989).

To come closer to the meaning in this dissertation, it is evident that researchers have also focused a great deal of attention on the individual-level antecedents of an innovation

(Standing et al., 2016). The influence of individual characteristics on an employee's ability to innovate has been noted to be significant (Da Silva & Davis, 2011).

### *Individual competence*

For this study, the definitions that emphasise individual-level innovation competence as the competence needed to be performed in complex and networked innovation development processes is of core interest, and not organisational-level competences as resources needed in the R&D processes of organisations or countries, nor the competence to adopt new technical devices. In the higher education context, Darsø (2012) defined innovation competency as an ability to create innovations by navigating together with others under complex conditions. Innovativeness has also been defined in higher educational contexts as creativity that involves the pursuit of putting a solution into practice (Siltala, 2010). According to Spencer and Spencer (1993), competence always involves an intention. In this dissertation, innovation competence is not generic innovativeness that can be useful in any situation, but the intentional capability of developing an innovation, a useful novelty made concrete and implemented to convey value – typically via multidisciplinary collaboration. It is the competence preceding innovation or innovative action related to it, and it is defined as the personal characteristics, skills, knowledge and attitudes that are needed for innovation in innovation processes in the sense of people's ability to innovate, produce innovations together with other people and companies, or otherwise behave in an innovative manner so that an innovation becomes possible (e.g. Chatenier, Verstegen, Biemans, Mulder, & Omta, 2010; Chell & Althayde, 2011; Montani, Odoardi, & Battistelli, 2014; Waychal, Mohanty, & Verma, 2011). In short, innovation competences are the abilities that refer to the knowledge, skills and attitudes needed in innovation development activities.

In professional higher education, learning outcomes are statements of what the learner is expected to know, understand and be able to do after successful completion of a process of learning (ECTS Users' Guide, 2015). The learning outcomes are mainly connected to learning contexts (Pikkarainen, 2014). The general term "competence" needs clarification in this context. Competence is the integration and manifestation of knowledge, skills and attitudes in the performance in a specific, pre-defined context and in concrete, authentic tasks (following Mulder, 2012; Mulder & Gulikers, 2011; Sturing, Biemans, Mulder, & De Bruijn, 2011). Mulder (2012) distinguished three perspectives for competence: behavioural functionalism, integrated occupationalism and situated professionalism. In this study, I follow Mulder (2012) in his definition of competence as situated professionalism, as it means that competence only holds meaning in a specific context in which professionals interact with each other. This is a relevant delimitation for the definition in this research context, and sets a valid focus for education when the target is to train professionals. The defined context herein is a collaborative project in a multidisciplinary team and it is defined and delimited as a means and motivation towards the goal. Pikkarainen (2014) has analysed that the most severe criticism on the weakness and ambiguity of the competence concept is addressed by Westera (2001), who suggests

that the competence concept should be altogether abandoned, at least in scientific educational discussions. According to him, there are two main problems. While competence is usually associated with successful performance in non-standard situations, it tries to give cognitive standards to behaviours that cannot be standardised. Secondly, competence does not offer any special new content in addition to the category of the cognitive skills that are involved in coping with complex problems. The narrowly economic, utilitarian, individualistic and ideological commitments of the discourse on competence have been criticised by many (Pikkarainen, 2014). One alternative concept that has been suggested is the capabilities approach (Lozano, Boni, Peris, & Hueso, 2012; Wheelahan & Moodie, 2011). The meaning of the concept is mostly defined as being able to perform effectively. According to Mulder (2012), Mulder and Gulikers (2011) and Sturing et al. (2011), competence is defined to integrate knowledge, skills and attitudes as an integrated entity that manifests itself in performance in a specific context and in concrete, authentic tasks.

In keeping with the European Qualifications Framework (EQF), the Finnish National Qualifications Framework (NQF) has eight levels covering secondary education, further education, vocational education and higher education. The bachelor's degree is at level 6. According to the NQF, there are recommendations for using generic competences and subject-specific competences in the curricula. In Finland, the competence-based curriculum is shaped by learning outcomes to which the education is geared. The competence-based principles of the curriculum determine teaching arrangements, student counselling and accreditation of earlier studies. In the Finnish framework competences are wide-ranging combinations of know-how – composites of knowledge, skills, attitudes possessed by an individual. Competences illustrate the person's proficiency, capacity and ability to perform in professional tasks. Education aims at enhancing the development of students' competences. Competences are categorised into subject-specific and generic competences (Using Learning Outcomes, 2011). Therefore, higher education institutions must not only facilitate students' professional competence-building within a certain academic field, but also the development of the generic competences that can be used outside the learning context (Nygaard, Hojlt, & Hermansen, 2008).

The competences needed in innovation processes can refer to knowledge, skills and attitudes (Zhuang, Williamson, & Carter, 1999), but the influence of individual characteristics also seems to be significant (Da Silva & Davis, 2011). Based on these preconditions, ***individual innovation competence is defined in this study as a synonym for a set of personal characteristics, knowledge, skills (or abilities) and attitudes that are connected to creating concretised and implemented novelties via collaboration in complex innovation processes.*** Similar to other competences, innovation competence can be learned and developed (Bruton, 2011; Peschl et al., 2014). According to Chatenier et al. (2010), personal characteristics are defined as the underlying traits that comprise an individual's personality and influence his or her



innovation behaviour. Personal characteristics are common across various situations and endure for a reasonably long period. It is not easy to distinguish a personal characteristic from a skill or attitude, as they clearly overlap (Avvisati, Jacotin, & Vincent-Lancrin, 2013; Celik, 2013).

The individual perspective on innovation is found to be underrepresented in the research (Peschl et al., 2014; Standing et al., 2016). However, there are many previous literature review studies on innovation competence from different perspectives and with different aims. Iddris (2016) sought to understand how firms develop their innovation capability to achieve competitive advantage along several dimensions: knowledge management, organisational culture, organisational learning, leadership, collaboration, creativity, idea management and innovation strategy. Mention (2012) identified how intellectual capital affects the innovation process, outcomes and performance of companies or firms, but did not specify the competence-related factors of an individual. Smith, Courvisanos, Tuck and McEachern (2011) examined company learning and development systems through human resource management. These studies investigated innovation capability at the firm or network level, not as individual competence. A study by Timmermans, Van Linge, Van Petegem, Van Rompaey and Denekens (2012) explored the factors that contribute to or hinder team learning in the innovation process, while Standing et al. (2016) focused on the role and actions of individuals in an innovation process setup, not in terms of competence. Thurlings and Evers (2015) aimed to unveil teachers' innovative behaviour and competence was narrowly understood as skill and knowledge. There are several innovation competence models with different innovation definitions that are created based on literature reviews.

Formulation of learning goals means that teachers are able to observe and document how students have achieved the learning goals, in order to justify students' learning. This creates a paradox according to Lund (2017), as innovation competence is politically desirable in education at the moment, but at the same time difficult to divide into measurable sub-goals. However, most of the competence studies in the higher education context present taxonomies to form evaluation criteria and imply that innovation competence can and should be measured in higher education (Keinänen et al., 2018; Kettunen, Kairisto-Mertanen, & Penttilä, 2013; Marin-Garcia et al., 2013). For example, Marin-Garcia et al. (2016) demonstrated the differences and similarities between several models and, based on this research, proposed a self-assessment survey method usable in educational and organisational contexts. Quantitative measurements of single competence factors (such as attitude factors) were analysed to understand learning. These measurements were based on self-evaluation. In the next chapter I will discuss how a learning experience is understood in this study. This is required to be able to grasp the meaning of competence and its relation to the learning experience and to be able to get ready to frame learning in terms of developing innovations.

## 2.5 Learning as an authentic experience and practical activity

### *Learning as experiencing, experimenting and growth according to Dewey*

Many scholars have observed that learning at school assumes the form of the reproduction of texts and other ready-made content by an individual to attain good grades (Dewey, 1916/1985; Engeström, 1987; Miettinen, 1990). This results in knowledge structures that are artificially delimited and not self-evidently usable outside the school context. This has been suggested due to the encapsulation of classroom learning from the activities of the surrounding society. Subjects should be taught in and with definite reference to their social context and use. Taken out of their social bearing, they cease to have social meaning and become abstract. Instead, students need educational experiences that enable them to act as valued, equal and responsible members of society. (E.g. Dewey, 1916/1985). John Dewey (1859–1952) has been named as the philosophical father of experiential education, which was called progressive education during Dewey's times. Dewey's three main publications focusing directly on educational philosophy were *My Pedagogic Creed* (1897), *Experience and Education* (1938/1997) and *Democracy and Education* (1916/1985). The description of his philosophy of the learning experience is limited to these publications, although he has discussed related matters in many of his other publications as well.

For Dewey, education served a broader social purpose of helping people be and act as more effective members of a democratic society. The one-way delivery style of authoritarian schooling does not provide a good model for life. Experience is a twofold affair, “an active and a passive element peculiarly combined” (Dewey, 1916/1985, p. 139). Meaning arises in social activity in a situation where the characteristics of an object in the environment are organised as functional consequences, as meanings in an activity between individuals (Miettinen, 2000). Dewey saw an individual student as an inherently social and active agent, not as superior by his intelligence to his surrounding world. He intentionally worked to get rid of the mind–body and subject–object dichotomies. Subjects and objects co-emerge and become interactively transformed in the practical activity. For literature, however, he saw a role: “I believe that literature is the reflex expression and interpretation of social experience; that hence it must follow upon and not precede such experience. It, therefore, cannot be made the basis, although it may be made the summary of unification” (Dewey, 1897, Article 3). Thus, he seems to have also abandoned the dichotomy between theory and practice.

Experimenting is seen as a natural way of action in educational experiences. “I assume that amid all uncertainties there is one permanent frame of reference: namely, the organic connection between education and personal experience; or, that the new philosophy of education is committed to some kind of empirical and experimental philosophy. But experience and experiment are not self-explanatory ideas. Rather, their meaning is part of the problem to be explored” (Dewey, 1938/1997, Chapter 2). Dewey emphasised the

meaning of “newness” and conflicting problems in a learning experience: “Unless a given experience leads out into a field previously unfamiliar no problems arise, while problems are the stimulus to thinking” (Dewey, 1938/1997, Chapter 7).

Learning is related to personal growth, as learning happens by gaining understanding of the meaning of present experiences and by growing the ability to direct future experiences (Dewey, 1916/1985). “We grow when learning opens up opportunities for future experiences” (Dewey, 1916/1985, p. 107). For Dewey, growth is an endless and repeatedly restarting individual process that constantly leads to new ways of action. Growth can be understood as depending upon the presence of difficulties to be overcome. Experiences are continually developing the individual by “shaping the individual’s powers, saturating his consciousness, forming his habits, training his ideas, and arousing his feelings and emotions” (Dewey, 1897, Chapter 1). Formal education cannot safely depart from this; it can only organise it or differentiate it. Education, which does not occur through forms of life that are worth living for their own sake, Dewey denounced as poor substitutes for genuine reality (Dewey, 1916/1985). Education should empower students to their full capacity and more. This can be interpreted as a suggestion for giving the mandate to students to trial and error by experimenting in collaboration: “the only possible adjustment which we can give to the child under existing conditions, is that which arises through putting him in complete possession of all his powers. With the advent of democracy and modern industrial conditions, it is impossible to foretell definitely just what civilization will be twenty years from now” (Dewey, 1897, Article 1). To give students the command of themselves today empowers them for continuous learning as part of the normal life stream: “I believe that education, therefore, is a process of living and not a preparation for future living” (Dewey, 1897, Article 2).

### *Student agency*

Dewey was very critical towards professionals in education dictating the content of learning based on some vague idea of the content that was useful in the life of the teachers themselves previously. Dewey sets no ends outside of the processes of education; “it is its own end” (Dewey, 1916/1985, p. 54). However, the idea that the end of education is growth seems to be paramount. It is up to practitioners to set the ends and their criteria for practices. Setting external ends would violate Dewey’s experiential conception of education. Rather than impose specific curricular aims, Dewey provides evaluative criteria so that citizens themselves can assess the educational and democratic value of any practice, curricula, or institution. Dewey seems to have trusted that “ordinary” educational actors (students, parents, teachers, administrators) have the capacity to determine their own ends: “In other words, the sound principle that the objectives of learning are in the future and its immediate materials are in present experience can be carried into effect only in the degree that present experience is stretched, as it were, backward. It can expand into the future only as it is also enlarged to take in the past. The educator more than the member of any other profession is

concerned to have a long look ahead” (Dewey, 1938/1997, Chapter 7). In fact, Dewey did not forget the meaning of conscious reflection, which he understood as a practical activity as well (cf. Miettinen, 2000). By reflecting on his own actions against others, the learner’s own instincts and tendencies gain meaning: “Thought or reflection ... is the discernment of the relation between what we try to do and what happens in consequence” (Dewey, 1916/1985, p. 144). When reflection becomes cultivated, experience, learning and reflection pass over to thinking as the deliberate or “intentional endeavor to discover specific connections between something which we do and the consequences which result, so that the two become continuous” and “reflection and thinking make planning possible, by the anticipation of certain outcomes or ends-in-view” (Dewey, 1916/1985, pp. 145–146).

On the other hand, Dewey was also critical of completely free, student-driven educational activity because students often do not know how to structure their own learning experiences for maximum benefit. The individual differences between people and the heterogeneity of participants in collaborative action are noted as resulting in a positive breaking down of barriers (Dewey, 1916/1985). He points towards ideal social conditions for learning and individual growth, but in a social and collaborative way. According to Dewey, an educator must take into account the unique differences between each student. Each person is different, also in terms of past experiences. The educator’s responsibility is to see to two things equally. First, that the problem grows out of the conditions of the experience being had in the present and that it is within the range of the capacity of students; and, second, that it is such that it arouses in the learner an active quest for information and for the production of new ideas; and third, to help in recognising learning: “Teachers are the agents through which knowledge and skills are communicated and rules of conduct enforced” (Dewey, 1938/1997, Chapter 1). The new facts and new ideas thus obtained become the grounds for further experiences in which new problems are presented: “A primary responsibility of educators is that they not only be aware of the general principle of the shaping of actual experience by environing conditions, but that they also recognise in the concrete what surroundings are conducive to having experiences that lead to growth” (Dewey, 1938/1997, Chapter 3). The teacher needs to be aware of the capacities, needs and past experiences of students: “The teacher’s suggestion is not a mold for a cast-iron result but is a starting point to be developed into a plan through contributions from the experience of all engaged in the learning process. The development occurs through reciprocal give-and-take, the teacher taking but not being afraid also to give” (Dewey, 1938/1997, Chapter 6). Connectedness to student growth must be the teachers’ constant responsibility. To conclude, a learning experience is understood in relation to a practical activity that takes into use previous experiences and competences and that allows for personal growth. The experience allows students to take a naturally active role in collaboration.

In the context of innovation projects, Dewey’s thinking seems very timely still today. The importance of experiencing learning as practical, real-life activity have been

emphasized also after Dewey to enable students to act as valued, equal, and responsible members of the society. Real experience has been the main source of inspiration for many scholars who have participated in an attempt to understand learning (see e.g. Illeris, 2007; Kolb, 1984; Kolb and Kolb, 2017; Miettinen, 1990; 2000). The severe dichotomy between individualistic approaches to learning and purely social interaction needs to be transcended. Therefore, the bridge between the ultimate individual perspectives and social and collaborative perspectives to learning in the professional higher education context (UAS) can be aided by the conception of agency. The conceptualisation of professional agency from subject-centred perspectives takes individual agency and social context to be analytically separate, but mutually constitutive and interdependent (Eteläpelto, Vähäsantanen, Hökkä, & Paloniemi, 2013).

When people are involved in creative processes in networked communities aiming at implementable outcomes, individuals are not seen as subjugated to organisational processes, but as dynamic and active agents with individual experiences and competences (Eteläpelto et al., 2013). These experiences and competences are important resources and opportunities. **Agency is practiced and manifested when individuals or communities exert influence, make choices and take stances in ways that intentionally affect their work or their professional identities.** It is closely intertwined with context and the competences of the participants (Edwards, 2010). Students' agency in project work in professional and collaborative networks is thus a relational capacity to align one's thoughts and actions with those of others to expand the object that one is working on (see Edwards, 2005; Edwards & D'Arcy, 2004). It is exercised for intentional purposes and within material circumstances. In relation to innovation development practices, agency is needed especially for development work and for taking creative initiatives, learning and for the renegotiation of work identities in constantly changing practices. Agency comes to the fore when actors set out to expand the object of their activity by recognising the motives and the resources that others bring into the interpretation (Edwards, 2010).

## 2.6 Learning to develop innovations as part of formal education

### *Project pedagogies*

Innovation education programs have been defined as any pedagogical program or process of training for innovation capabilities and skills, which involve personal, technical and organisational qualities; designed to empower both innovators and non-innovators with the tools necessary to undertake innovative activities (Maritz et al., 2014). Pedagogy is defined (following Alexander, 2008; Daniels, 2007; Edwards, 2001) in this study as a purposive cultural intervention in human development that is informed and shaped by the values and history of the society and the community in which it is located. Pedagogy is thus not only a matter of teaching methods and practice. A

pedagogy also includes the wider arrangements such as study materials and other pedagogical tools, grading and assessment practices, the distribution of authority, the organising of time and space, and implicit or explicit ways of communicating. Based on this definition, as part of formal education (meaning educational institutions with officially-approved curricula) set as the context in this study, pedagogy refers to the purposive interventions and their arrangements, the communities and their organisation and facilitation, and the supporting and mediating materials, facilities and implicit or explicit ways of communicating. *Innovation pedagogy* (e.g. Kettunen, 2011; Kettunen et al., 2013) has mostly been used for working-life–education projects in the UAS context. To date, innovation pedagogy has been defined broadly as integrating applied research, development and entrepreneurship with education, and as promoting networking based on the needs of working life (Kettunen, 2011). The meaning of quantitative competence assessment has been emphasised (see e.g. Keinänen & Oksanen, 2017; Keinänen et al., 2018; Kettunen et al., 2013; Marin-Garcia et al., 2013).

In the Finnish UAS context, there are many pedagogical orientations that emphasise the relationship between innovation development, project-based learning, work organisations and authenticity. Only a few of them transparently state their pedagogical grounds. For example, the “learning by developing” pedagogy and its philosophical grounds are based on pragmatism and learning is regarded more as a tool which facilitates the achievement of competences (Taatala & Raji, 2012). A closer look at the origins of the project method revealed several important aspects. The father of the project method, a colleague and a student of Dewey, William Heard Kilpatrick, developed and conceptualised it with a loose definition. He distinguished four types of projects. The first type represented those experiences in which the dominating purpose was to do, to make, or to effect: to embody an idea in “material” form. Writing letters and composing symphonies were activities that represented type-1 projects. The second type involved purposeful enjoyment or appropriation of an experience, for instance, a boy enjoying a piece of music or fireworks. In the third type of project, the dominating purpose was to solve a problem. The fourth type, the learning project, included experiences in which the purpose was to acquire some item or degree of knowledge or skill (Kilpatrick, 1921). According to Blumenfeld et al. (1991), the essence of project-based learning is that a question or problem serves to organise and drive activities; and these activities culminate in a final product that addresses the driving question (Blumenfeld et al., 1991). Adderley et al. (1975) provided the following definition for the project method, which has also been defined as a valid definition by Helle, Tynjälä and Olkinuora (2006): (1) [projects] involve the solution of a problem; often, though not necessarily, set by the student himself [or herself]; (2) they involve initiative by the student or group of students, and necessitate a variety of educational activities; (3) they commonly result in an end product (e.g. thesis, report, design plans, computer program, or model); (4) work often goes on for a considerable length of time; and (5) teaching staff are involved in an advisory, rather than an authoritarian role during any or all of the stages: initiation, conduct and

conclusion. The challenge of calling innovation projects project-based pedagogies is that it is challenging to know beforehand what the actual problems are that require solving. They emerge along the way and can form an unlimited problem space on many levels.

Taatala, Suomala, Siltala and Keskinen (2006) proposed that an innovation project is a social phenomenon that brings the competence of several individuals together through social processes supported by shared resources: An innovation project is a social process through which a novel idea is turned into a practical reality. Students should be able to produce multiple creative solutions to open-ended tasks to develop their competence in changing circumstances (e.g. Bencze, 2010; Cropley & Cropley, 2010; McLellan & Nicholl, 2011). These solutions are also often implemented in practice by bringing them into use to bring value to the students' surrounding world. Innovation project activities based on the processes are designed by teachers, firms and other working-life organisations together as problem- or project-based development activities that can be called pedagogical innovation processes (cf. Lepistö & Lindfors, 2015; Rautkorpi & Hero, 2017). To conclude, **a pedagogical innovation process is an authentic innovation activity in educational contexts whereby collaboratively-created ideas are transformed into a concrete end result, made concrete, prototyped and tested, and implemented to convey value in the surrounding world through interactions with several stakeholders** (cf. Peschl et al. 2014; Sawyer, 2006b). However, since authenticity is subjective, it is important that the learners perceive the activities as authentic (Cumming & Maxwell, 1999; Fook & Sidhu, 2010; Macht & Ball, 2016).

In this study, **an innovation project is a social phenomenon of learning that brings the competence of several individuals together in a social process through which a novel idea is turned into practical reality based on an open challenge from real working life and has a pre-defined intention to produce an innovation.** If the outcome is not an innovation *per se*, learning can still happen. This means that the process is in focus, not the project outcome (product, service etc.). In this research, innovation projects are seen as a purposive activity carried out in networked collaboration in order to recognise and proactively direct and develop the students, teachers and partnering working-life organisations' capabilities to produce and deliver (or plan the delivery of) a novel solution into use (see also Hasu, 2001).

### *Educational programs*

While discovering these pedagogical aspects and traditions of learning to develop innovations, several aspects were found to be important to understand from previous studies. The differences to entrepreneurial programs have been made clear by several scholars; however, pedagogical methods for optimal learning seem manifold. For example, Martiz and Donovan (2015) have noted that today, both entrepreneurship and innovation programs employ a variety of content, pedagogies and contexts. However, they noted the ultimate purpose of entrepreneurship education was to help entrepreneurs launch new ventures and understand the consequences of their decisions (Maritz &

Brown, 2013), whereas the purpose of innovation programs was to enhance the innovative performance of individuals and organisations (Donovan, Maritz, & McLellan, 2013; Maritz et al., 2014). According to Martiz and Donovan (2015), pedagogical initiatives involved, for example, interviews with practitioners, simulations for the tendering of patents, assigned readings, blended and online learning, role playing, guest speakers and engagement. These pedagogies are clearly more suitable to learning *about* innovation than about learning how to make an innovation through networked collaboration.

However, the importance of experiencing the innovation journey by oneself as a practical, real-life activity has been noted. For example, Gilbert (2011) studied a one-discipline pedagogical program moving from planning only to concrete prototyping that embraces learning led by creativity, informality, curiosity and emotion that immerses students in real-world problems and opportunities. Innovation development in the educational context has mainly been noted as action learning projects (Brazee & Lopp, 2012), where students work collaboratively to address a client's real-world organisational challenge through their concurrent learning and application of course content. This pedagogical approach has been noted to offer one strategy that is particularly well suited to learning to develop innovations (Brazee & Lopp, 2012; Claxton, Mathers, & Wetherell, 2005/2006; Marienau & Fiddler, 2002; Wilson & Fowler, 2005; Wyman, Holland, & Yates, 2012). Brazee and Lopp (2012) described the pedagogy as a process by which students engage in the project and develop learning strategies to accomplish the client's goal. The client offers students a challenge that holds significant, real-world consequences for the organisation and has no simple solution or single "right" answer. The most important consideration when setting up a group is ensuring wide diversity in its members' knowledge, perspectives and experience. This diversity can be incorporated into the group through the careful selection of members. When students embark upon an action-based innovation project, they face high levels of uncertainty and ambiguity while receiving little clear direction about what they will need to do to achieve the open goal. This active learning strategy seeks to engage students in cultivating their own learning processes by immersing them in the real-world context of a real-life problem. Innovation development learning projects has been investigated also in primary and secondary school context focusing on emotions and personal growth perspective (Lund, 2015, 2017). Lund (2015) found that the processes were sensitive to partnerships and external factors (time, evaluation procedures and values) and that the activity created insecurity and engagement due to the unpredictability. However, it is concluded, that if education tries to control and avoid unpredictable situations, supporting innovative students may be challenging, even compromised. Lund (2017) postulated that successful development and implementation of innovations may call for abilities to handle conflicts constructively, and found e.g. that this perspective is not reflected in the Danish school curricula. Also in higher education context Jensen & Lund



(2016) found the framing of experienced insecurity a neglected pedagogical challenge within a problem oriented learning approaches aiming at future innovations.

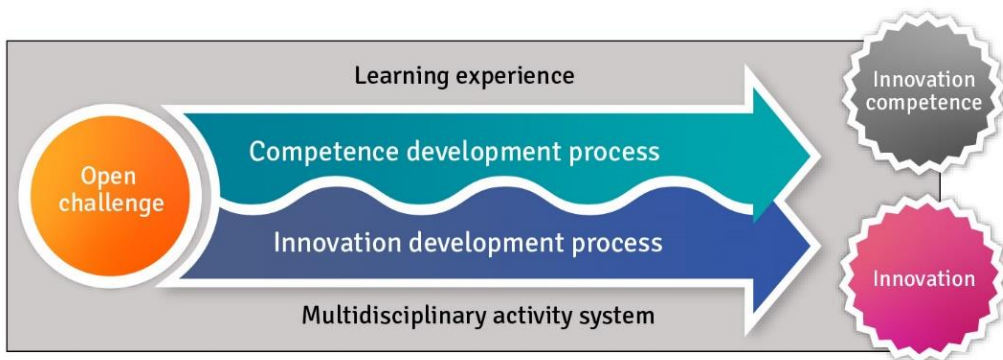
Real-life projects provide richly complex, real-world experience, through which students are able to become co-creators of their knowledge, conscious designers of the actions they take and reflective participants in shaping the professional paths they choose to follow. While studying the pedagogies of innovation learning, Kars-Unluoglu (2016) found that teachers in leading business schools have built into the curriculum case studies, creative group projects, workshops, guest lectures and student participation revolving around the discussion of assigned material to achieve the co-development of knowledge. The versatile nature of curricula and such wide variation in content for learning to make innovations suggests that we are in the early years of pedagogical development. To create a deeper understanding of innovation and develop an insight into what theories and approaches to utilise when engaging with innovation in real-life settings, instructors should shy away from traditional teaching approaches towards the explorative and iterative nature of the innovation process in an experiential fashion to allow for personal growth. Marienau and Fiddler (2002) summarise this as follows: “The well-worn path most educators encourage, if not require, students to travel is the byway of other people’s expressions of creativity, meaning-making, analytic thought, insights, and wisdom ... students need to follow another path as well – the path of their own experiences, on which they reconstruct understandings, perspectives, and, perhaps, themselves” (p. 14).

In the context of business studies, for example, Gilbert (2011) emphasised the powerful learning experience resulting from the authenticity, concreteness and real-life process of developing a novel product and planning, prototyping and experiencing “the path an innovation (which can be seen, touched, heard or smelt) will take to market” (p. 162). Only a handful of studies about innovation projects in higher education multidisciplinary contexts was found. Ness and Riese (2015) found that when specialists from different industries constructed common knowledge as a platform for their joint innovation project, they were aided by the ability to recognise each other’s competences and by having openness, curiosity and respect for each other’s experiences and views. Johnsen (2016) found that innovation is promoted by teamwork, multidisciplinary collaboration, mentor support and external partnerships. For individual participants, this meant navigating through uncertainty while being part of a team. Heikkinen and Isomöttönen (2015) found that multidisciplinary teams enable students to better identify their own expertise, which can lead to increased occupational identity. They further found that learning experiences are not fixed, as team spirit and student attitude play an important role in how students react to challenging situations arising from the multidisciplinary. Muukkonen et al. (2013) found that the task, learning objectives and outcomes as well as the appropriate ambition level defined together with the customer have an effect on student motivation, uncertainty and anxiety experiences.

To conclude, in higher professional education context, recent studies have focused on innovation pedagogies and competences (e.g. Kars-Unluoglu, 2016; Keinänen & Oksanen, 2017; Konst & Jagiello-Rusilowski, 2017; Marin-Garcia et al., 2016). Previous research on learning experiences in innovation projects exists primarily with respect to single-discipline higher education contexts (e.g. Gilbert, 2011; Keinänen & Oksanen, 2017; Liebenberg & Mathews, 2012; West & Hanafin, 2011). Only a few studies specifically addressed the multidisciplinary learning experience (e.g. Heikkinen & Isomöttönen, 2015; Johnsen, 2016; Muukkonen et al., 2013).

## 2.7 The theoretical framework at a glance

A summary of the theoretical framework for studying learning to develop innovations can now be presented for this study. In the theoretical framework (figure 1) the *open challenge* depicts the authentic problem as a starting point; *innovation* and *innovation competence* the intended outcomes; *competence development process* the learning related to personal growth (cf. personal characteristics and attitudes), skills and knowledge development; *innovation development process* the collaborative novel solution creation that students engage in teams. The *learning experience* refers to real-life experiences of breaking the habits in the collaborative activity of doing, exploration and reflection (Dewey, 1897, 1916/1985, 1938/1997). Each student's experience is different. The *multidisciplinary activity system* refers to the collective formation of a complex mediational structure for the engagement of individuals towards a defined goal or objective (cf. Engeström, 1987) involving participants from different professional or disciplinary fields. Competence development is tied to the innovation development process, and neither can exist without the other.



**Figure 1.** A theoretical framework for studying learning to develop innovations.

**Innovation** is a useful novelty that is made concrete and implemented to convey value (cf. Peschl et al., 2014; Sawyer, 2006b; 2009; West and Farr, 1990; Quintane et al. 2011) and innovation development process is a learning process *an sich* (e.g. Dodgson, 1991,

1996; Engeström, 1999; Hasu, 2001; Lundvall, 1988, 1992; Saari & Kallio, 2011; von Hippel, 1994, 1998; von Hippel & Tyre, 1995, 1996). The development of innovations originates from the need for new solutions that spring from complex problems in societies or from the underlying needs of people (Nandan & London, 2013; Sloep et al., 2014; Somech, 2006; Van Der Vegt & Bunderson, 2005). Complex problems benefit from diverse perspectives and cannot be solved by a single individual, authority or company (Jonassen et al., 2006; Kurtzberg, 2005; Van der Vegt & Janssen, 2003). Innovations are thus developed in networked multidisciplinary collaboration. **Multidisciplinary refers to an activity in which more than one discipline is involved in a collaborative team** (e.g. Morse, Nielsen-Pincus, Force, & Wulfhorst, 2007) that is a part of **an activity system**, a collective formation of a complex mediational structure of the engagement of individuals towards a certain goal or objective (Engeström, 1987). It involves a subject, a community, an object, tools, rules and the division of labour used in the activity, and the actions and operations that affect the outcome (Nardi, 1996). The object of the activity is the physical or mental product that is sought. It represents the intention that motivates the activity. An object in this case can be twofold: a concrete outcome or developed competence. Following Taatila et al. (2006), an **innovation project** is a social phenomenon of learning that brings the competence of several individuals together in a social process through which a novel idea is turned into practical reality based on an open challenge from real working life and has a pre-defined intention to produce an innovation. **Learning** is understood here as real-life experiences of breaking habits during the collaborative activity of doing, exploration and reflection, which enables continuous personal growth (Dewey, 1897, 1916/1985, 1938/1997). A **pedagogical innovation process** (Lepistö & Lindfors, 2015) is a real-life learning activity in the context of formal education in which collaboratively-created ideas are transformed into a concrete end result through interactions with several stakeholders (Hero, 2017; see Peschl et al. 2014; Sawyer, 2006b). At the centre of the activity is **an open problem or challenge from working life** and an object-oriented goal to produce a novel solution for such a problem.

The possibility of a new product, service or other solution was defined as based on the **complementarity of the knowledge** of the participants involved (Hakkarainen et al., 2004; Miettinen & Lehenkari, 2016; O'Reilly, Williams, & Barsade, 1998). In this study, an individual student is seen as inherently social and active, not as superior in terms of his intelligence to his surrounding world. The mind–body and subject–object dichotomies are hard to be deployed in this context, as subjects and objects co-emerge and become interactively transformed in the practical activity (e.g. Dewey, 1897; Eteläpelto et al., 2013). The **individual innovation competence** (as opposed to organisations, or even state-level innovation competence, or mere innovativeness as an ability to adopt new solutions or act in a creative way) is understood as a synonym for a set of personal characteristics, knowledge, skills (or abilities) and attitudes that are connected to creating concretised and implemented novelties via collaboration in

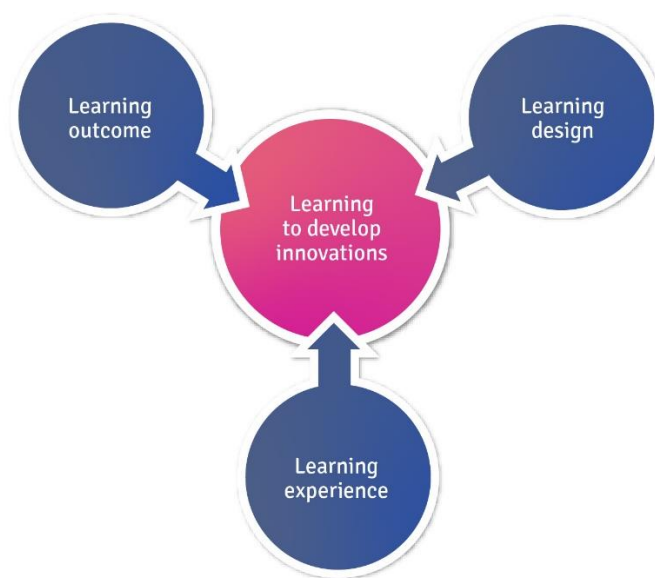
complex innovation processes. Similar to other competences, innovation competence can be learned and developed (Bruton, 2011; Peschl et al., 2014). The relevant factors for learning to develop innovations seems to be the competences needed in innovation development processes, the design principles and structure of the multidisciplinary activity system and the nature and outcomes of the learning experience. Based on the theoretical underpinnings, the research aims and questions are presented in the next chapter.

### 3. Aims and research questions

As presented in the previous chapters, learning to develop innovations is not a one-dimensional phenomenon, but always emerges as a result of a highly complex network of interactions. It is intrinsically social and cannot be understood as something that is accomplished by one individual. Although the potential value of multidisciplinary teams and learning in authentic development work remains clear in corporate contexts, the benefits for higher education pedagogies are still unclear. In-depth qualitative empirical studies are scarce, competence related to learning unclear and the teacher and student perspectives on learning are mostly missing. Although innovation processes benefit from collaboration (John-Steiner, 2000; Sawyer, 2003), students are often judged on how well they perform based on some form of individualised assessment (Sawyer, 2014). In addition, it is unclear what kind of activity systems support these aims and whether these systems actually promote student learning. From these starting points, a student-centred approach is relevant, as the learning experience may unfold the need for tutoring and activity system design.

This study examines the phenomenon of **learning to develop innovations** in multidisciplinary contexts in professional higher education (university of applied sciences). It looks for the factors relevant in learning to develop innovations in collaboration between education and working life. This dissertation's general part aims at unfolding this phenomenon to aid curriculum design and the pedagogical development of the learning opportunities.

Pedagogy was defined in this study (following Alexander, 2008; Daniels, 2007; Edwards, 2001) as a purposive cultural intervention in human development informed and shaped by the values and history of the society and the community in which it is located. In addition to teaching related practices, pedagogy also includes the wider arrangements such as study materials and other pedagogical tools, grading and assessment practices, the distribution of authority, the organising of time and space and implicit or explicit ways of communicating (following Alexander, 2008; Daniels, 2007; Edwards, 2001). Based on this definition, the relevant factors relate to teachers' work, purposive interventions and their arrangements, the communities and their organisation and facilitation, and the supporting and mediating materials, facilities and implicit or explicit ways of communicating.



**Figure 2.** Perspectives to study learning to develop innovations (delimitations).

The study was delimited to factors that can be considered relevant for curriculum design and pedagogy from three perspectives (figure 2): the learning outcome (i.e. the competence needed in developing innovations; sub-study I); learning design (i.e. the real-life activity system formation; sub-study II); and learning experience (i.e. how the activity system is experienced; sub-study III). These are considered relevant factors for the research perspectives of learning to develop innovations based on previous studies presented in chapter 2. To clarify, “learning outcomes” are competences that develop during activity and “project outcomes” are those products, services etc. that students produce in their projects.

The main research question for the study was: **What factors are relevant in learning to develop innovations in collaboration between education and working life?** The main aim of this dissertation was to explore the matter from different angles to be able to increase understanding of the relevant factors related to learning to develop innovations to aid curriculum design and the pedagogical development of the learning opportunities supporting this aim in the UAS context. The phenomenon was investigated based on recent research and teacher and student experiences.

The main question was formulated to integrate both theoretical and empirical aims from the perspectives of student learning, teaching and the activity system to benefit teachers and education providers to be able to design and facilitate learning to develop innovations by applying the findings. The main question springs from the needs identified during the theoretical considerations that laid the grounds for the study and

that responded to the research need. It is now possible to summarise the research questions.

Main research question:

What factors are relevant in learning to develop innovations in collaboration between education and working life?

The three sub-questions:

**Sub-study I:** What are the factors of individual innovation competence based on recent empirical research?

**Sub-study II:** What kind of multidisciplinary pedagogical activity system facilitates the development of innovation competence according to teachers?

**Sub-study III:** How do students in professional higher education experience their learning in a multidisciplinary innovation project?

In addition to the aims set for the sub-studies, some general aims have been set for this research as a whole (table 1.).

**Table 1.** Aims of the dissertation.

Main aim	To define the relevant factors in learning to develop innovations in collaboration between education and working life.			
General aims	<b>Theoretical aim:</b>  To deepen understanding of learning to develop innovations as an experience in the border zone of school and society.	<b>Empirical aim:</b>  To unfold multidisciplinary learning activities and to understand pedagogical opportunities.	<b>Methodological aim:</b>  To develop tools to study pedagogical activities intended for innovation competence development.	<b>Practical aim:</b>  To find insight for curriculum design, organising the activity, tutoring and assessment.
Specific aims	<b>Sub-study I:</b>  To define the factors of individual innovation competence.	<b>Sub-study II:</b>  To understand the characteristics of multidisciplinary activity system that can facilitate the development of innovation competence.		<b>Sub-study III:</b>  To find how students experience their learning in a multidisciplinary innovation project.

The empirical aim was to unfold these multidisciplinary learning activities and to understand pedagogical opportunities when the activity was formed around developing a novel solution within a network formed between working life and teachers and students from different disciplines. The theoretical aim was to develop theoretically optimal models to

study learning to develop innovations, to understand individual innovation competence and pedagogical innovation processes. These models aim at deepening the understanding of learning as an experience in the border zone of school and society, and opening up the concept of innovation from many points of view in terms of educational discourse. The methodological aim was to develop tools to investigate and develop further different types of innovation learning programs. These are today rather common (e.g. Brazee & Lopp, 2012; Claxton et. al. 2005/2006; Donovan et al., 2013; Kars-Unluoglu, 2016; Marienau & Fiddler, 2002; Maritz et al., 2014; Wilson & Fowler, 2005; Wyman et al., 2012), but still quite little researched from pedagogical perspectives (Maritz et al., 2014). The practical aim was to find pedagogical grounds for curriculum design, organising the activity by understanding the pedagogical process and tutoring and assessment.

The main research question is answered in this dissertation by bringing together the conclusions of the sub-studies and the factors relevant in learning to develop innovations in collaboration between professional education and working life presented as a conclusion. The research findings are discussed in relation to the set general aims and then concluded in the final chapters of this dissertation.



## 4. Short overview of the sub-studies

This chapter gives a short overview of the sub-studies. The complete published articles can be found at the end of this dissertation.

### *Sub-study I*

Sub-study I aimed to define individual innovation competence and factors related to the competence needed in innovation processes based on recent empirical research. The research question was: What are the factors of individual innovation competence based on recent empirical research? This information is crucial to be able to design, tutor and assess the pedagogical processes where authentic open-ended tasks are being solved, transforming novel ideas into usable products or services. The individual perspective was regarded as important as the assessment of learning is still conducted individually for each student even though the learning often happens in teams and networked systems. The other rationale for the individual perspective was that of the preliminary finding that there is not much research on this perspective. Consequently, the study was set to offer an overview of the individual innovation competence usable in educational settings to promote innovation learning (Lindfors & Hilmola, 2016). The secondary aim was to find avenues for future research in this important area of cross-disciplinary research.

This study was important to conduct, as learning for innovation is a central element in European policymaking in developing higher education and because students often learn in project settings together with work organisations to develop new solutions, products and services. These authentic creative, social and collaborative settings offer an attractive learning environment. After defining the extraction criteria using a limited sample of articles, a bias-assessed systematic review was conducted of empirical research articles published from 2006–2015. Twenty-eight journal articles were ultimately included in the review. Despite the volume of academic literature in this field, comparatively few studies providing findings addressing the review objectives could be found. There was, however, a reasonable weight of research evidence to support the results. The findings suggest that personal characteristics such as flexibility, achievement orientation, motivation and engagement, self-esteem and self-management, future orientation, creative thinking skills, social skills, project management skills and content knowledge and making skills may all be needed in collaborative innovation processes. These findings have implications for pedagogical innovation processes and for competency-based assessment.

### *Sub-study II*

Sub-study II aimed to understand what kind of activity system facilitates the development of innovation competence from the teachers' perspective. It examined innovation tournaments as a multidisciplinary pedagogical activity system for the development of innovation competence in an institutional context that combined vocational secondary (vocational education and training, VET) and tertiary, professional higher education (university of applied sciences, UAS) students. The focus was on the design of the activity system and the solutions found by the teachers in the design phase concerning the system components: subject, community, object, rules, tools and the division of labour. It was important to investigate this as the need to strengthen the contribution of education in terms of innovation requires action across all higher education institutions, and the practical models for pedagogies are still scarce. This study took the results from sub-study I into use and set its objective based on it. It examined the development phase of a multidisciplinary pedagogical activity system that aimed at the development of innovation competence defined in the first sub-study. It focused on the collaborative planning and piloting phase of the multidisciplinary innovation projects; namely, an innovation tournament in a multi-grade and multidisciplinary context. The focus of this study was on the tensions and solutions in the collective design of an innovation tournament activity system. The aim was to understand the macro-level activity system by studying the solutions that teachers found for the activity system components. The design phase was unfolded to be able to formulate such a systemic model. The co-design by the teachers from secondary vocational and professional higher education (i.e. UAS) revealed the tensions and solutions in planning the structural and procedural characteristics of the goal-oriented activity system. The goal was to model the activity system based on the solutions found by the teachers in the planning, piloting, execution and evaluation phases of the development process.

The research question was: What kind of multidisciplinary pedagogical activity system facilitates the development of innovation competence according to teachers? The method used was a theory-based qualitative activity system analysis, and the research material consisted of annotated teacher–producer planning meeting videos. The analysis was delimited to the talk about the activity system components: the subject, the community, the object, rules, tools and the division of labour (adapted from the activity system model by Engeström, 1987, 2014). The study found tensions and solutions for the learning subject and community formation, as well as for the tournament object formation concerning tasks, ways of working, assessment methods and the challenges from companies. The study also found solutions for tournament rules, the division of labour and tools such as processes, methods for choosing the winners, prizes, assessment criteria and the technical tools. To support the development of innovation competence, the multidisciplinary activity could be organised in phases such as the orientation (future orientation, innovation theory), idea, concept, prototype and testing, implementation, entrepreneurship and multiple assessment phases. The study concluded with a model of

a pedagogical activity system design for teachers' pedagogical use. Future research in this area should focus on assessment methods for innovation competence.

### *Sub-study III*

Collaboration between universities and industry is increasingly perceived as a vehicle to enhance innovation. Educational institutions are encouraged to build partnerships and multidisciplinary projects based around real-world open problems. Projects need to benefit student learning, not only the organisations looking for innovations. The context of this study is a multidisciplinary innovation project, as experienced by the students of a UAS in Finland. The purpose of the study was to unfold students' conceptions of the learning experience, to help teachers and curriculum designers to organise optimal conditions and processes, and support competence development. The research question was: How do students in professional higher education (ie. UAS) experience their learning in a multidisciplinary innovation project?

The study took a phenomenographic approach. Data was collected in the form of weekly diaries, maintained by the cultural management and social services students ( $N = 74$ ) in a mandatory multidisciplinary innovation project in professional higher education in Finland. Diary data was analysed using a data-driven, thematic inductive analysis. The results of the study revealed that students understood the learning experience in relation to solvable conflicts and unusual situations, becoming aware of and claiming collaborative agency and internalising phases of an innovation process. The competences that students could name related to content knowledge, different personal characteristics, emerging leadership skills, creativity, future orientation, technical, crafting and testing skills and innovation concretisation and implementation-related skills such as productisation, marketing, sales and entrepreneurship planning skills. However, future orientation and implementation planning skills were found to be weaker than other variables in the data were. The findings suggest that curriculum design should enable student-led pedagogical innovation processes that involve a whole path from future thinking and idea development, through to prototyping, to implementation planning of the novel solution. Teachers should promote deep comprehension of the innovation process, monitor and ease the pain of conflict if it threatens motivation, help in recognising gaps in individual competences and development needs, promote more future-oriented, concrete and implementable outcomes, and facilitate in bridging between the project and entrepreneurship. The multidisciplinary innovation project described in this study provides a pedagogical way to connect schools to the practices of society.

## 5. Methods

This chapter introduces the methods used in the sub-studies. A research methodology helps make visible not only the outcome, but also the process of scientific inquiry (Cohen, Manion, & Morrison, 2007). First, the methodological foundation is presented, the participants of the studies are introduced, and the data collection and data analysis are described. In addition, the methodological actions taken towards the triangulation of the results and to enable the rigor of the research are presented.

### 5.1 Research process and methodology

This study applied a multi-method qualitative research approach. A qualitative approach was adopted to gain an in-depth understanding of the phenomenon of learning to develop innovations and of the relevant factors for curriculum design and pedagogical planning and assessment. Addressing the specific aim and research questions guiding this dissertation required theoretical knowledge and previous research results as qualitative material (sub-study I), but also the perspectives and views of different actors involved in the processes of practical innovation projects (sub-studies II and III). The methods in relation to the research questions are presented in table 2.

**Table 2.** Methods, materials, participants and analysis methods of the sub-studies in relation to their research questions (sub-studies I–III)

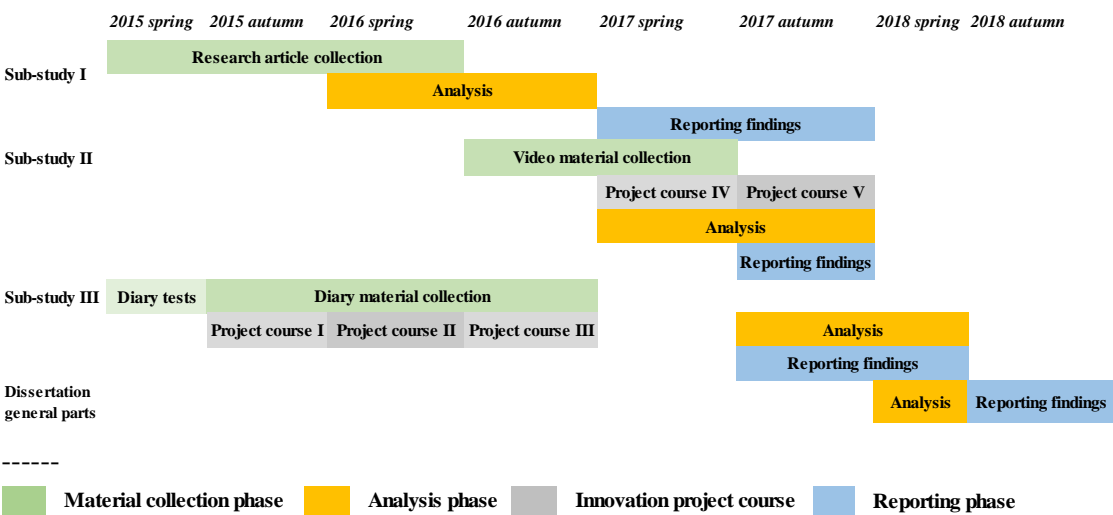
Sub-study	Research question	Method	Material	Participants	Analysis method
I	What are the factors of individual innovation competence and possible avenues for future research?	Systematic review	N = 28 peer-reviewed, academic research articles	-	Content analysis and multiple reviewer bias assessment
II	What kind of multidisciplinary pedagogical activity system facilitates the development of innovation competence according to teachers?	Activity system analysis	12 h 4'21" teacher development meeting videos over 1 year	N = 17 teacher forum members	Theory-driven content analysis of tensions and solutions in collaboration based on the activity system model
III	How do students experience their learning in a multidisciplinary innovation project?	Phenomenography	N = 74 student diaries	N = 37 cultural management and N = 37 social services students	Data-driven, thematic inductive analysis

Qualitative research holds that there is no single knowable reality that can be accessed as all understanding is filtered through human beings. Knowledge is constructed and interpreted, therefore it is relative and specific (Kezer, 2006). Individuals develop varied meanings of phenomena; it is the role of the researcher to uncover these complexities in the views held. Thus, the qualitative researcher depends on studying participants' views to find meaning in the phenomenon being studied (Creswell, 2009) and is him or herself an "instrument" in the study (Denzin & Lincoln, 2005). This highlights the fact that reality is a social construct that relies on individuals' subjective views, which are shaped by historical and social factors and personal experiences. The qualitative approach was suitable for examining the views of teachers while collaborating in developing a novel pedagogy and students while working in a multidisciplinary team developing an innovation by the given definition of the word; a novel product or other concrete

outcome with working life to be taken to the market or otherwise into use to convey value.

The research process in sub-studies I–III was not linear, as the material collection and analyses were partially overlapping (table 3).

**Table 3.** Research process and timing.



After the research planning phase in 2014, the material collection for sub-study I started at the beginning of 2015 and lasted for one semester. The material was later doubled in spring 2016 to allow for more generalisable results. At the same time, in spring 2015, the diary template for sub-study III was tested by gathering material from a multidisciplinary innovation project course based on the same curriculum as the final material. After the test, the template was finetuned and the material was collected during three project course implementations (project courses I–III). At the same time, with the last of the collected diaries in autumn 2016, the video material collection started and lasted for one academic year. The video material from the meetings was gathered while teachers were planning and piloting project courses IV–V.

*Systematic review of sub-study I*

A systematic review on individual innovation competence was conducted 2015–2017. In sub-study I, published research articles from 2006–2015 in peer-reviewed, academic journals were collected using an explicit method to identify, select and critically appraise relevant research data (see Greenhalgh, 1997; Higgins, 2008; Peticrew & Roberts, 2006). The method was chosen when the lack of bias-assessed systematic reviews on individual innovation competence became obvious (see sub-study I). The method was regarded as a reliable method to study the recent research-based understanding of

individual innovation competence to find the factors defining it. Systematic reviews attempt to collate all empirical evidence that fits pre-specified eligibility criteria in order to answer a specific research question. It was chosen as a review method as it uses explicit, systematic methods that are selected with a view to minimising bias, thus providing more reliable findings from which conclusions can be drawn and decisions made. The benefit of the method is that it has been found to advance rigor as it is an iterative process guided by scientific methods, has a specific pre-defined set of criteria in all stages, and it is transparent, accountable and the methods are reproducible (Greenhalgh, 1997). The benefit of combining the results of several studies is that it can give more reliable and precise findings than one study alone, or subjectively, even randomly chosen studies. The method has its roots in medical research that informs policymakers and healthcare decisions for individual patients. Public policy should be informed by the best available research evidence. There are also limitations in using this method. It is very resource intensive. The exhaustive material collection takes many months; in this study, almost a year. Nevertheless, there is no guarantee that all the research is collected or that it is able to offer insights into the research question. In addition, the researcher needs to be careful that the concepts are defined in the same way as in the research question (see Higgins, 2008; Petticrew & Roberts, 2006). For this study, the method was suitable, as the preliminary scoping of the studied concept was defined so as to define the extraction criteria, and the bias assessment of the material was possible within the research group (see sub-study I). The collected research articles were treated as qualitative empirical document data and analysed in a systematic manner.

A preliminary search of the term *individual innovation competence* yielded no results. However, the concept *innovation competence* seemed to be used with several meanings. The search criteria and terms were brainstormed among all three authors. The following search terms were used: *innovation competenc\**, *innovativeness*, *innovation capability/ies*, *competence to innovate*, *innovation ability/ies* and *innovation skill/s*. Synonyms were employed because the term *individual innovation competence* is not an established concept. The systematic identification of studies was limited to databases based on their relevance to the field of education. The chosen databases were EBSCO (including ERIC, CINAHL and nine others), PsychINFO (including ProQuest/Education and Psychology) and Scopus. The search was limited to 10 years (2006–2015) to yield a reasonable, still adequate sample of peer-reviewed studies.

#### *Activity system analysis in sub-study II*

The focus of sub-study II was on the teacher team members' ("Teacherforum") collaborative design of a multidisciplinary activity system for learning to develop innovations. The pedagogical development of a multidisciplinary activity system aiming at innovation competence (as defined in sub-study I) was studied based on teachers' views. It adopted an activity theory-based method; namely, activity system analysis (ASA), which is generally used for developing constructivist learning environments (Jonassen & Rohrer-Murphy, 1999). ASA is a method based on naturalistic inquiry

(Yamagata-Lynch, 2010; see also Denzin & Lincoln, 2005) aimed at understanding a macro-level collaborative activity system. The benefit of the method is that it offers a structured way to organise the analysis based on system theory and takes into account the many different parties involved in an activity. Another benefit is that its origins are in an educational research tradition (see Engeström, 1987), and it is suitable for depicting a complex learning environment in a thick way (Jonassen & Rohrer-Murphy, 1999). It can also provide a means through which to systematically analyse human interaction while considering how an individual or group of individuals and their interactions with the environment affect their activities (Yamagata-Lynch, 2010). The limitations of the method are that it only offers an analysis method with theory-based criteria and not an ideal for data collection, and it has been criticised for ignoring individual cognitive development and its relationship to human activity, cognition, psychology and cultural settings (Toomela, 2008), that it is difficult to learn (Nardi, 1996) and that it delimits the ability to understand complex human interactions (Yamagata-Lynch, 2010). However, for the research design adopted in sub-study II, it offered a structured way to analyse tensions and solutions in teacher interaction towards a pedagogical system suitable for learning to develop innovations.

As the basic “sources of innovation” (see e.g. Hakkarainen, Palonen, Paavola, & Lehtinen, 2004, p. 111) have been defined e.g. as overcoming tensions, contradictions and ambiguities for something that is not there yet by questioning the existing practices (Engeström, 1987, 1999, 2016), the tension-solution trajectories were chosen as the basic analysis framework to study the activity system development among “Teacherforum” members, that came from different disciplines (sub-study II). Contradictions have been defined as the driving force of change in activity when people representing different organisations with different aims collaborate (Engeström, 2001). “The fourth principle is the central role of contradictions as sources of change and development. Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between activity systems.” (Engeström, 2001, p. 137) Activities are open systems. When an activity system adopts a new element from the outside (for example, a new technology or a new object), it often leads to an aggravated secondary contradiction where some old element (for example, the rules or the division of labor) collides with the new one. “Such contradictions generate disturbances and conflicts, but also innovative attempts to change the activity. If we want to successfully confront the various actors involved, we must be able to touch and trigger some internal tensions and dynamics in their respective institutional contexts, dynamics that can energize a serious learning effort on their part.” (Engeström, 2001, p. 140) Based on this thinking, the analysis framework for studying the development of a multidisciplinary activity system to promote innovation development was designed as tensions and solutions talk related to the AT model determinants subject, the community, the object, tools, rules and division of labour. (Engeström, 1987).

There are several applications of the method as a descriptive tool to identify systemic contradictions and tensions that shape developments in educational settings (Barab,



Barnet, Yamagata-Lynch, Squire, & Keating, 2002; Roth & Tobin, 2002) and those provided insight into the optimal ways to gather the material and to analyse it in addition to the methodological guides (Jonassen & Rohrer-Murphy, 1999; Yamagata-Lynch, 2010). In addition, ASA was chosen as it offered an opportunity to structure the findings in a model that can easily be later compared to other activity systems designed in the same way. It was regarded as of utmost importance, as the designing of the right types of activity systems (Engeström, 1987) to facilitate innovation learning (Bruton, 2011; Lindfors & Hilmola, 2016; Sawyer, 2014) can have immediate, observable effects on competence development (Pant, 2012; Amabile, 1996).

The observations were collected in a real environment during the teachers' development meetings. Videotaped observations can be time consuming and overwhelming; however, they provide investigators with first-hand experience of participants' everyday activities (Merriam, 2009). The meetings were videotaped over one year in the planning, piloting, execution and evaluation phases of the development process. The process was unfolded by documenting it to be able to formulate a clear picture of a real, difficult and systemic learning environment design under development and in its pilot phases. The co-design by the teachers revealed tensions and solutions in planning the structural and procedural characteristics of the goal-oriented activity system. The advantage of using ASA in sub-study II was that it provided a method to extract the essence of complex data sets in a graphic model, and these data sets could then be compared with those of other similar system studies later in further research (Yamagata-Lynch, 2010).

### *The phenomenographic approach in sub-study III*

Sub-study III adopted a phenomenographic approach as it aimed to find the qualitatively different ways in which students experienced their learning in a multidisciplinary innovation project; a similar activity system to that of sub-study II. Phenomenography, developed by, for example, Marton (1986), is a qualitative research strategy framework with an ontological presupposition. Phenomenography is related to a field of knowledge, which is defined by having experience as the subject of the study. It takes a non-dualistic ontological perspective, where the object and subject are not understood as separate and independent from each other (Kettunen & Tynjälä, 2018). Phenomenography is an empirical research tradition that has been designed in an educational context to answer questions about learning, and it has been applied mainly in educational research. In phenomenographic research, the researcher chooses to study how people experience a given phenomenon. It does not study a phenomenon *an sich*. To compare the two, empirical phenomenology searches for immediate experience instead of conceptual thought, whereas phenomenography does not make this distinction as a starting point of the research (Marton, 1986). Phenomenography explores the qualitatively different ways in which people potentially experience certain phenomena they meet in their worlds (Marton, 1986; Marton & Pong, 2005). Phenomenographers understand a learning experience as a "nondualist model of experience" (Linder & Marshall, 2003, p. 272),

rather than depicting it in the form of abstract mental models. This is in line with Dewey's thoughts (cf. Dewey, 1897, 1916/1985, 1938/1997).

In its early years, phenomenography was criticised for lacking explicitness concerning data collection and analysis (e.g. Richardson, 1999). Its validity and reliability has also been questioned, but, for example, Åkerlind (2005) has emphasised that because phenomenography makes no claims about the "truth" of its results, external measures of validity may not apply. Instead, "communicative validity" (an accurate description of the procedures) and "pragmatic validity" (the meaningfulness of the results for the intended audience) are more meaningful in evaluation. Providing a strong rationale by offering a comprehensive literature review and methodology and showing research gaps, articulating a clear statement of purpose and the relevant research question are important for the credibility of the study (Hays, Wood, Dahl, & Kirk-Jenkins, 2016).

In sub-study III, phenomenographic interviews were first considered for collecting the material, but eventually a diary method was chosen to enable the conceptions of the experience to be grasped during the project, not only afterwards. Post-project interviews or surveys would have given a different answer to the research questions that were posed. A survey or interview method in data collection was feared to affect how students would experience the project. This decision was made to understand the experience as it happened (cf. Dewey, 1938/1997), not only as it is memorised after the project. Semi-structured diaries were considered as a fair way of listening to students' voices along the innovation project, as they themselves want them to be heard.

Finally, in this general part of the dissertation, the results from the sub-studies were triangulated to be able to present answers to the main research question. Qualitative studies can rely on multiple sources of data, which offers an opportunity for triangulation to get a multidimensional understanding of the studied phenomenon (Creswell, 2009; Denzin & Lincoln, 2005) and to advance validity (Cohen et al., 2007). The triangulation in this general part relied on three data sources and the conclusions from the sub-studies and offered views on the phenomenon to discuss the factors related to it. The methods were chosen for each sub-study separately to ensure that they fitted with the aim of the study's research question, but so that they also complemented each other to provide insights into the main research question of the dissertation.

## 5.2 Material collection

Three types of research materials were collected during 2015–2017: research articles (articles published over 10 years from 2006–2015, collected during 2016) for sub-study I; Teacherforum meeting video material during one school year (autumn 2016–spring 2017) for sub-study II; and student diary material during three semesters (autumn 2015, spring 2015 and autumn 2016) for sub-study III (see table 2).

The research process for sub-study I started by unfolding the concept of individual innovation competence. The inclusion and exclusion criteria were first set by thematising a limited sample of the data. This was necessary as the core concept of innovation competence seemed to have tens of meanings and the concept was used vaguely in many different contexts. To develop a picture of the concept of innovation competence, an existing evidence base was first scoped. A scoping review is a specific type of review that can provide a structured approach to the gathering of background information on a topic (Arksey & O'Malley 2005; Armstrong, Hall, Doyle, & Waters, 2011; Brien, Lorenzetti, & Lewis, 2010; Levac, Colquhoun, & O'Brien, 2010). A scoping review can precede systematic reviews (Greenhalgh, 1997; Petticrew & Roberts, 2006) to thoroughly define the concept. According to Arksey and O'Malley (2005) and Levac et al. (2010), scoping reviews are appealing since they produce broad evidence and provide a map or a snapshot of the existing literature without quality assessments or extensive data synthesis. Concept definition information is often acquired in an ad hoc fashion (Armstrong et al., 2011), but in this study it was an important phase to be able to design the extraction criteria and to delimit the concept to cover only those competences that are needed in developing innovations. In this scoping phase, material from the EBSCO databases (limiters: peer-reviewed, only 5 years, 2009–2014) was collected and used as a sample ( $N = 524$ ) to determine the extraction criteria. The initial inclusion criteria was *includes definition of innovation competence or its defined synonyms*. When categorising the resulting articles, six larger categories of approaches and contexts were found for the concept of innovation competence and its synonyms. Most of the articles examined the innovation competence of organisations (e.g. Kodama & Shibata, 2014; Wang, 2014), country-, region- or area-level innovation capabilities or competences (e.g. Chen et al., 2009; DiPietro, 2009) or the innovativeness of non-human things such as innovative software (e.g. Lim et al., 2011). Consumer innovativeness was used in the context of the diffusion or adoption of novel products or technological goods. In the context of marketing, communication or consumer studies, individual-level innovativeness was defined, for example, as the ability to adopt, try, buy or accept innovations, and it was then defined as a person's ability to understand, receive, socially estimate, spread, implement and use innovations (e.g. Manning, Bearden, & Madden, 1995), but not to create them. Extraction criteria were thus defined as concerning: (1) organisations (organisation, industry, firm and product programmes); (2) geographical areas (such as country and region); (3) non-human entity innovation competence (i.e. animal, product, policy, fashion and marketing); (4) innovation competence defined as a technological device or other new thing adoption (diffusion or adoption of innovation); (5) the publication not being a peer-reviewed academic research journal; and (6) not being empirical research. The discipline, or field of research, was not used as an exclusion criterion since innovation concerns many disciplines and paradigms. The inclusion criteria were redefined as: (1) includes the definition of innovation and innovation competence or a synonym defined in this study; (2) concerns individual human beings; and (3) empirically tests factors of innovation competence.

The final sample consisted of  $n = 28$  articles that matched the inclusion criteria. Key information from the selected articles was defined, including the article title and year, context, study design, study population, subjects and overall risk-of-bias assessment. The included studies represented the studied phenomenon. Ten of the studies were conducted in an educational context (higher education, secondary or comprehensive education), while 14 occurred in an organisational context (organisational psychology, human resource management or business studies) and four studies occurred in both contexts (educational and organisational). Six of the studies were qualitative, 19 were quantitative, and three used mixed methods. Nine of the studies were case studies, two of which were multiple case studies. The study design and research methods varied considerably (sub-study I).

Concerning sub-study II, the research material consisted of annotated planning meeting videos. The material consisted of multidisciplinary and multi-grade teacher–producer workshop observations that were videotaped. The material was collected during autumn 2016 and spring 2017 in workshop meetings aiming at a pedagogical model for the *Innovation project 10 ECTS* course in a UAS in Finland. The workshop meetings were held before the first innovation tournament pilot, after it and while planning the second pilot. Therefore, the material consists of the experiences and learnings from one pilot course and the enhancements and corrections teachers felt they should make for the second one.

For sub-study III, the data was collected in the form of weekly diaries, maintained by the cultural management and social services students ( $N = 74$ ) in the same mandatory multidisciplinary *Innovation project 10 ECTS* in professional higher education in Finland. The curriculum was the same as in sub-study II. Diaries provided an opportunity to examine participants' activities and reflections in their daily environment (Iida, Shrout, Laurenceau, & Bolger, 2012). The diary was a Word template to be completed on a weekly basis. The form concluded with several open-ended questions for the self-assessment of cooperation within the team and with the customer, as well as what more the student would have liked to have learned. Students understood that the diary was first read by the tutor, after which the diaries were collected for research purposes as confidential material in which the student's identity could not be recognised.

The diary template for sub-study III was tested by gathering material in a multidisciplinary innovation project course based on the same curriculum as the final material. The test material consisted of  $N = 86$  diaries from students from different disciplines. The experiences of the diary template were discussed in innovation project teachers' meetings. The research material was collected over the course of three semesters in 2015 (autumn and spring) and 2016 (autumn). The final sample size was decided only after the first reading of the material and the first coding rounds. Thirty-seven diaries in each group of students of cultural managers and social service students seemed to reach the saturation point in thematisation. The final sample comprised  $N = 74$  diaries. The material included 1480 weekly entries and 370 open-question answers.

### 5.3 Analysis methods and processes

The data was analysed via qualitative content analysis (Braun & Clarke, 2006; Elo & Kyngäs, 2008; Mayring, 2014). A thematic analytical approach was the main method employed for data analysis in all articles. Thematic analysis is a fundamental and widely used method of analysis in qualitative research for identifying, analysing and reporting patterns; that is, themes within data (Braun & Clarke, 2006). It goes beyond word or phrase counting by identifying and describing both implicit and explicit ideas (Guest, MacQueen, & Namey, 2012). It is an analysis method to find meanings and intentions from the text or speech via the systematic classification of data according to the specific interest. It was carried out either in a data-driven, that is, inductively (categorisation based on data) or a theory-driven manner, that is, deductively (categorisation based on earlier knowledge) (Braun & Clarke, 2006; Guest et al., 2012). Units of analysis – that is, reference units (Krippendorff, 2013) – were defined based on the research questions and according to the methodological approach to the analysis (inductive–deductive). In sub-study I, the reference unit was a competency factor based on the definition in the theory section of the study: In sub-study II, a discussion event presenting a tension–solution trajectory related to the activity system model determinants (Engeström, 1987), and in sub-study III, a sentence, group of sentences, or a part of a sentence discussing the same topic.

The analysis of the first sub-study was conducted using an inductive, data-driven content analysis of the research literature gathered for the systematic review (following Krippendorff, 2013). The sampling of the chosen material was done by organising the data, evaluating the definition of innovation and extracting the competency factors. Coding was completed by one author and then, separately as a blind review, by the two other authors to limit subjectivity. After several discussions, the inter-reviewer agreement reached 100%. The semantic analysis was aimed at exploring the meaning that was derived from the relationships among the concepts in the text (Cohen et al., 2007). After coding, the thematisation of the subclass and the main classes was conducted by two authors and discussed until agreement was reached.

In the first phase of sub-study II, the videotapes were annotated (see e.g. Derry et al., 2010; Sloetjes & Wittenburg, 2008). The part-to-whole deductive approach introduced by Erickson (2006) was applied in annotating the material. The annotated events in this case were defined to be those presenting a tension–solution trajectory (part) related to the AT model determinant subject, the community, the object, tools, rules and division of labour (whole) (Engeström, 1987). The analysis focused on the discussion passages that constructed the content of collaborative development. The data consisted of tension–solution trajectories that reveal the solutions to activity system components. First, each annotation document was reorganised with the procedural dialogue into trajectories of tension–solution talk. Tension talk was defined as a discussion that results in either a positive or a negative critique or debate. Solution talk was defined as the resolution of

the tension or as an agreement or decision made. These were identified by the criteria “catalyses discussion among participants and needs a solution to allow them to proceed further in the development of the activity system, i.e. the tournament model”. Second, the tension talk and the solution talk were coded in episodes by conducting a data-driven, systematic qualitative content analysis (Krippendorff, 2013) through a careful re-reading and thematisation of the data. The coded trajectories of the analysis were again organised according to the six components of the activity system framework (Engeström, 1987, 2014; Jonassen & Rohrer-Murphy, 1999) to unveil the entire activity system. In conclusion, the analysis frame used the components of subject, community, object, rules, tools and the division of labour.

The data-driven content analysis (Krippendorff, 2013) of sub-study III was conducted by first reading the diaries twice, and then inductively thematising the content piece by piece to themes identified according to content. One reference unit was a sentence, group of sentences, or a part of a sentence discussing the same topic. First, the identified variation in meanings was categorised by description (e.g. Marton, 1981). These categories were not pre-determined but were constituted on the basis of the collected data. The first phase of the analysis focused on identifying and describing the participants’ ways of experiencing the phenomenon by reading and re-reading the data. Repeated readings afforded greater familiarisation with the data. By focusing on the similarities and the differences in the expressed meanings, the cases of variation were identified and themed accordingly. The initial categories of description were further elaborated, adjusted and defined according to the most characteristic features of each category (cf. Kettunen & Tynjälä, 2018). In the second phase, the second author participated in a blind review. The purpose of this phase was to guard against subjectivity bias and blind spots, and to avoid drawing conclusions too early. Finally, conceptions of the learning experience were categorised according to qualitatively distinct descriptions.

The results from the sub-studies were triangulated to be able to determine answers to the main research question. The results of sub-study I were used as a basis for pedagogical planning and this was then tested and piloted in practical pedagogical action planning (sub-study II). As the material collection for sub-study III had already begun before the analysis phase of sub-study I, it adopted a data-driven approach. However, the results were later triangulated with the findings from other sub-studies in this general part of the dissertation. To conclude, this general part forms the final research phase with its own research question, theoretical frame and the findings from sub-studies triangulated to answer it. In the next chapter, the methods to approach validity and the rigor of the sub-studies are presented.

## 5.4 Methods to advance rigor and ethical research conduct

My own role as a teacher in a Finnish UAS offered an opportunity to experiment with pedagogies and collect materials in authentic multidisciplinary teamwork circumstances. It also drove me to be very conscious in terms of material collection and my objectivity as a researcher. Transparency in methodological descriptions, material collection, multi-reviewer blind analysis and the open declaration of limitations are thus of utmost importance in this study. However, it also needs to be considered as a limitation especially in regard to the analyses of the materials.

During all the sub-studies, several bias-assessment methods were applied to control the material selection and analysis to increase the rigor of the research. To avoid subjectivity in the content analysis, researcher triangulation (Denzin, 1989) was applied in sub-studies I and III. The transferability of a study to other contexts and the applicability of the findings at other times can be strengthened by thick descriptions of the research process and results (Guba & Lincoln, 1994). Thick descriptions were provided in the sub-studies and deepened in this dissertation. They include reporting on how the reasoning and research processes have evolved, under which contexts and conditions the research took place and what the details were regarding the studied participants, collaborative conditions and content analysis reference units.

In sub-study I, several precautions were taken to ensure rigor of the systematic review research process and analysis. First, the inclusion and exclusion criteria were first set by thematising a limited sample of the data. Second, the data extraction path was documented based on the methodical tradition (Greenhalgh, 1997). In addition, a method for bias assessment was developed (see appendix 1). The final research data was subjected to this three-author bias assessment to make the quality of the material as transparent as possible and to avoid possible reviewer subjectivity bias (sub-study I). Third, the coding was completed by one author and separately validated as a blind review by the two other authors to limit subjectivity. After several discussions, the inter-reviewer agreement reached 100%. The analysis aimed at exploring the meaning that was derived from the relationships among the concepts in the text (Cohen et al., 2007). To increase reliability, the thematisation of the subclasses and the main classes was conducted separately after coding by the first and second authors and it was discussed until agreement was reached. Fourth, the thematisation of the factors found in the data was cross-validated by all three authors against the competence factors of the studies assessed to contain no risk of bias. The validation criteria were designed as a three-fold criterion: 1) studies with no risk of bias including large-scale quantitative studies in an *educational* context in which the minimum requirement was < 200 informants, and 2) in an *organisational* context in which the minimum requirement was < 200 informants, as well as 3) qualitative studies with no risk of bias (sub-study I).

In sub-study II, several preconditions had to be taken into account in the research process while observing video recordings and while analysing the material with the ASA method that applied theory-driven content analysis. First, I had participated in the meetings myself as a researcher and an informant in collaborative discussions and acted as a project lead in the planning process. It was important to realise beforehand that an activity system investigator needs to consider his/her role in the study (Jonassen & Rohrer-Murphy, 1999). Investigators can take on many roles in the participant–observer continuum, but the best method for gaining first-hand knowledge of participant experiences is to become a full participant in the community (Glesne, 2005). This role may provide investigators with access to information that the participants only feel comfortable sharing with their peers. I facilitated the meetings and participated in the discussions, so I needed to regard myself as a full participant. The benefit of participating was that the participants openly shared their thoughts and they trusted that their opinions were heard. Second, a systematic approach was used to collect the video material in the activity system development meetings and while annotating it. In the analysis phase, I assumed the role of an observer and handled the material word by word. It was acknowledged that annotation was a time-consuming process, which contains a risk of bias when done by only one annotator (Derry et al., 2010). This risk was controlled by using ELAN annotation software to be able to go back in version histories, listen to the material several times and go back and forth to consider the thematisation. A transparent analysis process was applied by transcribing most of the material in the annotation process. The anonymity of the participants was controlled for by using only the sound of the video in the annotation. However, it could not be guaranteed, as the annotator was present in the meetings. This might have affected the analysis (see section 7.6 for the methodological evaluation of this dissertation).

In sub-study III, in a phenomenographic analysis process, the main control for the researchers' interpretations was a strict adherence to data. This involved constantly going back to the data as a whole, and reading and re-reading the material. The NVivo 10 program was used to encode the reference units and track the stages of the analysis to ensure the rigor of the process. However, to increase the reliability of the analysis, a blind cross-review by the second author was undertaken. The second author coded 15% of the data during the first phases of the analysis without consulting the first author's thematisation. After that, the findings were discussed until an agreement was found for the themes. In addition, the second author acted as the “devil's advocate” by probing the preliminary categories created in these first rounds to guard against subjectivity bias and blind spots, and to avoid drawing conclusions too early (see Bowden & Green, 2010).

This research project has tried to carefully follow good ethical practices proposed by Tenk (2013). The managers responsible for research at the participating university and vocational institution were asked for their permission to undertake sub-studies II and II and their consent was received in writing. In addition, for sub-study II, the consent to videotape and use the material for the explained research purposes was asked orally and



recorded in the first recorded meeting. While annotating the video material, the analysis did not concentrate on who said what, but on the discussion trajectories communicating tensions and solutions. The final data (i.e. the video annotations) was preserved and archived in the researcher's computer and has only been seen by the researcher.

All of the teachers involved were informed about collecting the diaries from the students for sub-study III. The consent from the students was asked for in the diary template by first explaining the aim of using the diary anonymously afterwards for research purposes in this dissertation. The diaries were collected by asking the students to send them by email without their names on them. When an email came in, the file was numbered without opening it and the email destroyed. Later, when the analysis phase began, it was impossible to connect the diary with the individual who sent the email. The participants could refuse to participate by not sending their diary or by not ticking the box that asked for consent. The participants could contact the researcher if they wanted more information about the study. Moreover, the template pre-test allowed for the rigor of the process.

## 6. Findings from the sub-studies

### 6.1 Sub-study I: Individual innovation competence

Sub-study I (Hero et al., 2017) contributed to the educational aim that emphasises the responsibility to prepare students to collaborate in solving future problems and producing innovations in areas that presently do not exist (Sawyer, 2006a, 2012, 2014; Zang et al., 2011). By understanding competency outcomes, innovation processes can be more efficiently harnessed for educational purposes to foster learning. The learning process can be organised to address competence development. Regarding the innovation process as a learning platform, successful competency development during the process is the core target.

According to sub-study I, individual innovation competence relates to the personal characteristics, attitudes, skills and knowledge needed in intentional collaborative novel solution creation processes whose outcome is aimed at being an innovation. Seventy-one competency factors were identified, and they were organised into 17 sub-categories and a further 6 upper categories. The upper categories were identified as personal characteristics, future orientation, creative thinking skills, social skills, project management skills and content knowledge and making skills.

**Table 4.** Individual innovation competences based on academic research published from 2006–2015 (Hero et al., 2017)

Upper category	Sub-category	Competency factors
Personal characteristics	Flexibility	Flexibility; Sense of humour
	Motivation and engagement	Motivation; Engagement
	Achievement orientation	Ambition; Takes initiative; Goal orientation and generation; Learning goal orientation; Achievement and value orientation
	Self-esteem	Self-esteem
	Self-management	Self-management; Self-efficacy and control; Ability to focus on tasks; Persistence and conscientiousness; Ability to perform well under pressure
Future orientation	Future thinking	Future orientation and creative visioning; Visioning
	Alertness to new opportunities	Alertness to new opportunities; Openness to experiences; Curiosity; Proactiveness; Ability to cope with non-routine tasks and uncertainties; Risk-taking ability; Moderate resistance to change
Creative thinking skills	Creativity skills	Creativity; Imagination; Inventiveness; Ability to generate new ideas and solutions; Ability to do things differently; Problem-solving skills
	Cognitive skills	Learning skills; Ability to rapidly acquire, exchange and combine knowledge; Cognitive skills; Analytical thinking; Skills in thinking; Ability to combine and interpret; Willingness to question your own and others' ideas
Social skills	Collaboration skills	Cooperation skills; Teamwork skills; Social astuteness and sensitivity; Interpersonal management; Interpersonal influence; Championing; Ability to motivate others; Ability to build trust; Ability to mobilise the capacities of others
	Networking skills	Ability to create partnerships; Internal and external networking
	Communication skills	Communication; Ability to make your meaning clear to others; Presentation skills; Ability to write reports, memos or documents; Ability to write and speak in a foreign language; Negotiation skills; Active listening; Brokering (information exchange)
Project management skills	Process management skills	Ability to manage collaborative knowledge creation processes; Project management skills; Planning skills; Ability to use time efficiently; Research and development skills

	Management skills	Decision-making skills; Leadership skills
Content knowledge and making skills	Content knowledge	Mastery of one's own field or discipline; Knowledge of other fields or disciplines
	Making skills	Designing skills; Prototyping skills; Skills in making (know-how); Esthetical and psycho-motor skills
	Technical skills	Technical skills; Ability to use computers and the internet

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Based on this review (Table 4, Hero et al., 2017), in the collaborative activity of innovation processes, a successful participant should have good self-esteem and achievement orientation, be flexible, motivated and engaged with the task at hand. Future orientation is needed to remain alert to new experiences and opportunities for innovation. Creative thinking skills help in idea generation and problem solving, while cognitive skills help acquire, exchange and combine new knowledge in the form of analytical thinking. The ability to combine and interpret information as well as the willingness to question ideas are included among creative thinking skills. Social skills form the largest competency category in individual innovation competence. According to the analysis, personal communication skills are needed to make one's intentions clear to others. Networking skills are important in creating partnerships and building relationships. Interpersonal communication and management skills are needed for productive cooperation. As part of individual innovation competence, project management skills are important for finishing the innovation process through the efficient use of time and decision making. Content knowledge about one's field or other fields as well as making skills in the form of designing, prototyping, making and using technical equipment comprise the sixth competency category of innovation competence. Knowledge of other fields than one's own content knowledge or discipline is required in the innovation process (Bjornali & Støren, 2012; Cobo, 2013).

## 6.2 Sub-study II: A multidisciplinary innovation project as a pedagogical activity system

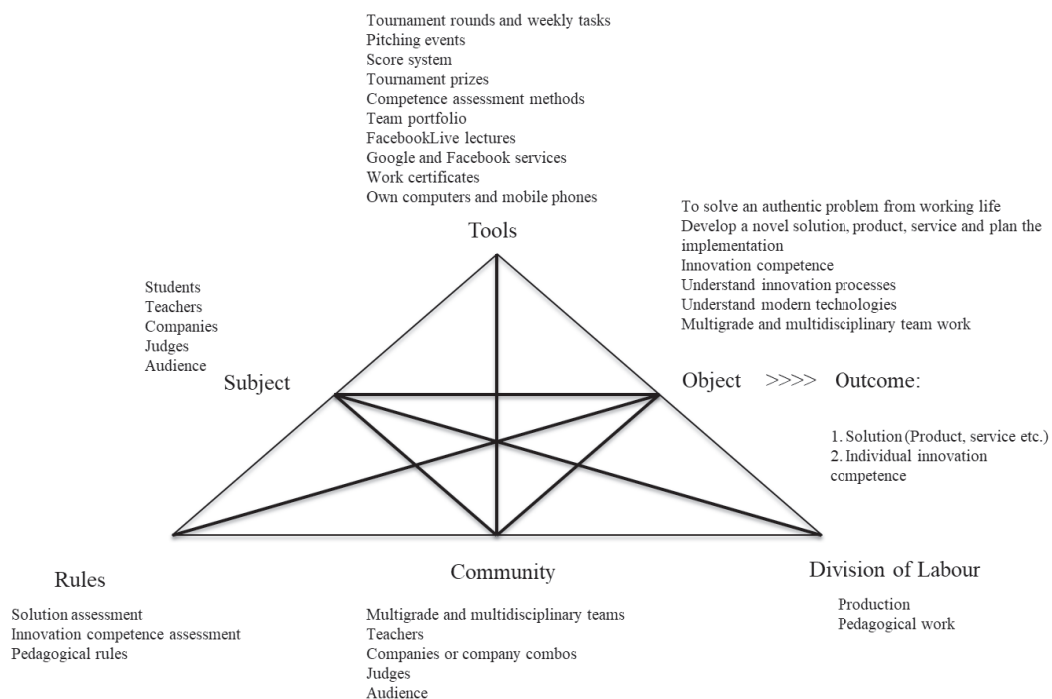
The focus of sub-study II was on the collaborative design of the multidisciplinary activity system and the solutions found in the design and piloting phases concerning the following system components: subject, community, object, rules, tools and the division of labour (Engeström, 1987). The aim was to find out what kind of multidisciplinary pedagogical activity system would facilitate the development of innovation competence (sub-study II).

Sub-study II found tensions and solutions in object formation concerning students in terms of tasks, assessment and ways of working; concerning teachers in terms of

assessment methods, the teachers' role and competence; and concerning the participating companies in terms of open and authentic challenge (i.e. task) formation and negotiation. The rules of the tournament created tension, but solutions were mostly found. The teachers separated the rules of the tournament and the pedagogical rules as a project course. The rules concerning the solution assessment criteria and the scoring system that the judges used were unclear, but these were clarified for the next pilot. Furthermore, the team competence assessment criteria and the selection of the winning team created tensions that needed solutions before the model could be planned. The tensions and solutions in the tools of the tournament were related to the process phases, the methods for choosing the winners and prizes and the technical tools needed in the tournament. The solutions related to pedagogical tools concerned tasks, lectures and tutoring, and individual student assessment. However, most of these tensions were resolved via the multidisciplinary collaboration of teachers and the production staff. From the solutions, the development of an innovation tournament activity system framework was possible.

A multi-grade and multidisciplinary activity system was designed as a teacher forum collaboration between VET and UAS teachers to achieve innovation outcomes for companies and organisations and competence development for students. Multi-grade teaching refers to the teaching of students of different ages, grades and abilities in the same group (e.g. Miller, 1991), and multi-grade grouping to involving different grades of students in a team (e.g. Leton & Anderson, 1964). The targeted innovation outcome was defined as a new product, service, or other solution, planned to be taken into use or taken to market with participating companies. The findings of this study confirm the expected complexity of bringing innovation tournaments into multidisciplinary and multi-grade institutional contexts. The tensions in the teacher design process to find solutions for the subject, community, object, rules, tools and the division of labour were manifold and complex, but not severe or impossible to solve. The solutions found for these components enabled the formation of the activity system.

The optimal pedagogical innovation process as a tournament for this context was designed to be an authentic task-based learning environment following the innovation process. In this process, collaboratively-created ideas are transformed into a concrete end result, prototyped and tested, and implemented to convey value in the surrounding world through interactions in a networked community. In conclusion, for the purposes of learning, an innovation project cannot aim at idea development only, which is what short innovation tournaments generally do (e.g. Duverger & Hassan, 2007). In formal education, an innovation project can possibly be organised in weekly rounds to unfold the innovation process phases to form a clear picture of the process. Doing so can increase understanding of the innovation processes for later application in working life.



**Figure 3.** Innovation tournament activity system (Hero, 2017; adapted from Engeström, 1987, 2014).

The results of sub-study II are summarised in figure 3. They are formed based on the solutions found to the tensions in discussions in the Teacherforum collaboration. According to the participating teachers, a learning subject (Engeström, 1999) in a pedagogical innovation process in this context is not only a single student, but a networked multidisciplinary and multi-grade team. The required stakeholders constituting the community with the students were judges who boost entrepreneurship and competence development, committed firms as weekly coaches, teacher pairs, older student tutors with their own specialisation, a tournament producer and a tournament manager. The process-oriented learning environment requires authentic and inspiring challenges from firms and organisations, the development of a team innovation climate, peer-tutoring for translating the activity into learning during the process, new kinds of competence assessment criteria and methods, and inspiring facilities. The co-activity between secondary and tertiary vocational students in multidisciplinary teams was found to be challenging because of the students' different levels of competence and abilities in taking responsibility independently. Designing the right types of activity systems can have immediate observable effects on competence development (Pant, 2012; Amabile, 1996). Teachers found the competence development motivational objective to be needed in the institutional context; the main goal is learning during the process and not just developing a successful solution for the company partner. A model of an activity system

was organised in seven weekly rounds with weekly tasks: the orientation (future, innovation concept), idea, concept, prototype and testing, implementation, entrepreneurship and assessment rounds. The design of the rounds met the preconditions – i.e. it enabled the development of innovation competence (sub-study I) – of future orientation in the orientation round, creative thinking skills in the idea round, project management skills in the project-based way of working in the team, content knowledge in the idea and concept rounds, and making skills in the prototype and testing round. The community was organised to support the creation of the vision, to facilitate idea generation and to foster the creation of new solutions to authentic problems. It also allows social interaction in the form of team projects to incorporate project management activities. Moreover, the activity system allows for the design of useful solutions. Multidisciplinary team formation enables multiple perspectives and skill variety for the complementarity of knowledge (cf. Hakkarainen et al., 2004; Miettinen & Lehenkari, 2016; O'Reilly et al., 1998) and new knowledge interfaces, while also introducing students to other disciplines.

This study contributes to research on innovation tournaments (Adamczyk et al., 2012; Boudreau et al., 2011; Duverger & Hassan, 2007; Füller, 2006; Kay, 2011; Konst & Jagiello-Rusilowski, 2017; Malhotra & Majchrzak, 2014; Morgan & Wang, 2010; Pedersen et al., 2013) with several findings. If tournaments as longer and intensive multidisciplinary innovation projects are introduced as part of curricula in professional higher education, several conclusions should be taken into account. The activity system should be designed to promote the whole innovation process, not just the first idea phases. Students' innovation competence development requires a longer learning experience than only 1–2-day “hackathons” (Duverger & Hassan, 2007) to offer an experience of the whole process from future thinking and idea development to planning implementation, even potential entrepreneurship opportunities could be considered as a student benefit. The practical project work should be multidisciplinary as competences complement solutions development (Miettinen & Lehenkari, 2016). The objective of the innovation project cannot only be a novel product or service for the customer company, but innovation competence for students is the primary target. Assessment should focus on innovation competence and solutions development. Self- and peer-assessment methods are not adequate in tournaments. Collaborative workshop methods with practical competence assessment tools are needed to make the strengths, weaknesses and competence development needs transparent. Assessment of and reflection on learning is needed at the beginning, in the middle and at the end of the project work to promote learning and give teachers the opportunity to monitor and support the experience and ease the pain of conflict and contradiction (sub-study III).

### 6.3 Sub-study III: Learning experience in multidisciplinary innovation projects

Sub-study III aimed to find the qualitatively different ways in which students conceptualise their learning experience during an innovation project to give insights to teachers and curriculum designers in higher education institutions to design better pedagogies. The aim was to find out how students experience their learning in a multidisciplinary innovation project. The findings suggest that the conceptions of the learning experience in a multidisciplinary innovation project relate to: (1) solvable conflicts and unusual situations; (2) becoming aware of and claiming collaborative agency; and (3) internalising phases of the innovation process (table 5).

**Table 5.** Students' learning experience in a multidisciplinary innovation project (Hero & Lindfors, in press)

<i>Main category</i>	<i>Category</i>
Becoming aware of and claiming collaborative agency	Independently work responsibly
	Competence awareness
	Actively building team competence
Getting through solvable conflicts and unusual situations	Collaborating by communicating
	Content knowledge that is not specified in advance
	Team co-operating within a network
	Personal development
	Outcome not defined in advance - Set by team
Internalizing an innovation process model	New types of environments
	Innovation theory, methods
	Development project management
	Creative thinking
	Future orientation
	Concepting
	Making a prototype
	Planning implementation
	Getting and giving feedback

First, much of the students' experienced learning related to solvable conflicts and unusual situations caused by multidisciplinary and open tasks. The multidisciplinary caused and gave the opportunity for learning about content that was not possible to



define in advance. Many students found the customers' role too small, and teachers were mentioned only a few times. The most meaningful network comprised of serendipitous meetings with other teams' members from different fields and those external professional networks that were needed to complete the product in practice. Contradictions in teamwork were related to positively experienced personal identity development in terms of flexibility, self-esteem and self-management, but also to learning collaborative problem solving. The open task required much proactive initiative, responsibility, motivation and achievement orientation; most students found that they learned how to tolerate uncertainty.

Second, students found they had learned how to work responsibly and independently, both as a team member and as an individual, how to explicate and make use of other people's competence in new situations, ways to actively build and develop the team towards the best possible outcome, and how to collaboratively communicate and negotiate within the team and with external customers. Multidisciplinary innovation projects benefit from the ability to recognise each other's competences and previous experience. Students also found that they had learned to recognise and express their own strengths, weaknesses and development needs. Multidisciplinary teams enable students to better identify their own expertise. This potentially enhances students' own ability to set learning goals by themselves and for teachers to identify competence gaps for more targeted tutoring.

Third, the innovation process and concept seems to be internalised as something that students can participate in making, but it requires many different people and wider networks. The students found that they had learned innovation process phases such as idea development and future visioning, as well as advances towards more reasoned concepts. These are crafted into a product or service prototype that is tested. A plan is developed as to how it can be taken to the market by producing branding, marketing and budgeting solutions and finally considering whether there would be a business or other type of entrepreneurship opportunity. These findings mainly promote the meaning of a direct experience resulting from a "path to innovation" as recognised process phases. Students emphasised the meaning of methods and tools that helped the necessary work and project management. Giving feedback to others and getting it in many phases was of utmost importance to students' learning experience. However, future orientation and implementation planning skills were weaker than the other variables in the data were.

The competences students recognised as developed in a multidisciplinary innovation project in sub-study III related mainly to: (1) innovation theoretical content knowledge, their own and other's discipline content knowledge, content knowledge that is not specified in advance; (2) personal characteristics (tolerating uncertainty, self-management, flexibility, self-esteem, taking initiative and responsibility); (3) emerging leadership skills (development project management: actively building team competence, encouraging and coaching others and the division of labour); (4) creativity; (5) future orientation; (6) technical, crafting and researching skills (concepting and making a

prototype and testing it); and (7) marketing, sales and entrepreneurship planning skills (implementation planning). However, future orientation and implementation planning skills were weaker than other variables in the data were. Compared to previous research, this study contributes to the multidisciplinary innovation pedagogy research era by unfolding the student conceptions of the learning experience in detail and as a whole, as the students were capable of reflecting on their experience from many angles.

## 7. Discussion and conclusions

This study examined learning to develop innovations in the context of professional higher education in universities of applied sciences. The dissertation aimed at unfolding this phenomenon to aid curriculum development and the pedagogical design of authentic learning opportunities supporting this aim. Based on this dissertation and its general part and the sub-studies, it is now possible to discuss the findings of the sub-studies, the theoretical framework presented in this dissertation and suggest answers to the research question of the dissertation: **What factors are relevant in learning to develop innovations in collaboration between education and working life?** The relevant factors for learning to develop innovations can be summarised under six topics that can guide curriculum development and pedagogical design: competence factors, factors related to assessment, pedagogical processes, organising the activity, the teachers' role and opportunities for tutoring and the use of the concept "innovation" when referring to outcomes from student work in education. In addition, some theoretical and methodological considerations, limitations and practical implications are presented and avenues for future research are proposed.

### 7.1 Competence factors

Individual innovation competence relates to the personal characteristics, attitudes, skills and knowledge needed in collaborative novel solution creation processes whose outcome is aimed at being an innovation (Da Silva & Davis, 2011; Zhuang, Williamson, & Carter, 1999). Based on sub-study I, competence related to innovation involves several types of personal characteristics, future orientation, creative thinking skills, social skills, project management skills and content knowledge and making skills (sub-study I, e.g. Arvanitis & Stucki, 2012; Avvisati et al., 2013; Bruton, 2011; Chatenier et al., 2010; Edwards-Sachter, García-Granero, Sánchez-Barrioluengo, Quesada-Pineda, & Amara, 2015; Montani et al., 2014; Nielsen, 2015; Waychal et al., 2011; Vila, Perez, & Coll-Serrano, 2014). As competence is the integration of knowledge, skills and attitudes in the performance in a specific, defined context and in concrete, authentic tasks (following Mulder, 2012; Mulder & Gulikers, 2011; Sturing, Biemans, Mulder, & De Bruijn, 2011, see also Da Silva & Davis, 2011), the competency variables presented in sub-study I would form a holistic entity useful in authentic innovation development activity. Sub-study I concluded that in the collaborative activity of innovation processes, a successful

participant should have good self-esteem and achievement orientation, be flexible, motivated and engaged with the task at hand. Future orientation is needed to remain alert to new experiences and opportunities for innovation. Creative thinking skills help in idea generation and problem solving, while cognitive skills help acquire, exchange and combine new knowledge in the form of analytical thinking. The ability to combine and interpret information as well as the willingness to question ideas are included among creative thinking skills. Social skills form the largest competency category in individual innovation competence. According to the analysis, personal communication skills are needed to make one's intentions clear to others. Networking skills are important in creating partnerships and building relationships. Interpersonal communication and management skills are needed for productive cooperation. As part of individual innovation competence, project management skills are important for finishing the innovation process through the efficient use of time and decision making. Content knowledge about one's field or other fields as well as making skills in the form of designing, prototyping, making and using technical equipment comprise the sixth competency category of innovation competence (sub-study I).

The competences students could conceptualise as developed in a multidisciplinary innovation project in sub-study III related mainly to: (1) innovation theoretical content knowledge, their own and others' discipline content knowledge, content knowledge that is not specified in advance; (2) personal characteristics (tolerating uncertainty, self-management, flexibility, self-esteem, taking initiative and responsibility); (3) emerging leadership skills (development project management: actively building team competence, encouraging and coaching others and the division of labour); (4) creativity; (5) future orientation; (6) social skills (the team co-operating within a network, collaborating by communicating); (7) technical, crafting and researching skills (concepting and making a prototype and testing it); and (8) marketing, sales and entrepreneurship planning skills (implementation planning). However, future orientation and implementation planning skills were weaker than other variables in the data in sub-study III were. The findings in sub-study III partly supported the findings in sub-study I, even though the study was not conducted in a theory-driven manner based on the first sub-study. Ability to cope with non-routine tasks and uncertainties (Chatenier et al., 2010; Keller, 2012) and moderate resistance to change (Celik, 2013; Gundry, Ofstein, & Kickul, 2014) seem to describe tolerating uncertainties, which was found as one of the factors describing students' learning experience in sub-study I. The related leadership skills were described as development project management skills, the ability to actively build team competence and encouraging and coaching others. These were described in the results of the first sub-study more generally as project management and leadership skills.

The most meaningful and clear addition to the competences listed in sub-study I was implementation planning skills described as marketing, sales and entrepreneurship planning skills. These were found important in pedagogical innovation processes in sub-study III, but were not found in sub-study I. In addition, the required content knowledge

gained a more exact meaning in sub-study III, as it was described as innovation theoretical content knowledge, own and other's discipline content knowledge and content knowledge that is not specified in advance. This supports Dewey's thinking in that the exact ends of the learning experience are not possible to define in advance (Dewey, 1916/1985). Still, by understanding competency outcomes, innovation processes can be more efficiently harnessed for educational purposes to foster learning. The learning process can be organised to address competence development (sub-study I), however, learning outcomes cannot be set in detail in advance (sub-study III). The competence development motivational objective is needed, as in the context of formal higher education, the main goal is learning during the process and not just developing a successful solution for the company partner (sub-study II).

To conclude, it is possible to propose some factors based on sub-studies I–III to direct assessment discussions, reflections and where the tutoring teachers could focus their continuous observation (figure 4). Those factors are personal characteristics such as self-esteem, self-management, achievement orientation, motivations and engagement, flexibility and responsibility, future orientation, creative thinking skills, social skills such as networking, collaboration and communication skills, development project management skills, implementation planning skills such as making, productisation, sales, marketing and entrepreneurship planning skills and one's own and other's discipline content knowledge. By acknowledging the strengths, weaknesses and competence development needs of the participant students in a multidisciplinary project, it is possible to discover the opportunities provided by the complementarity of knowledge (Miettinen & Lehenkari, 2016) and support individual students' learning in teams.



**Figure 4.** Individual innovation competence, IIC (based on Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press).

If Dewey (1897, 1916/1985) and the teachers in sub-study II were to be followed, the competence list does not provide a solution for quantitative measurement at the end of the project. Self-, peer- and working-life partner assessment was clearly more meaningful to students than teachers' formative assessment. The competence model is potentially suitable for steering peer discussions, developing practical collaborative tools for assessment, but not for measuring the "absolute" competence development at the end

of the project when it is already too late to adjust the activity and steer the teams and individual students for learning.

## 7.2 Factors related to assessment

If growth is an endless and repeatedly restarting individual process that constantly leads to new ways of action by experiencing difficulties that need to be overcome (Dewey, 1916/1985), real-life conditions offer an opportunity to assess the experience based on the competence to overcome challenging situations and an unlimited problem field. If education should empower students to their full capacity and exceed it by giving them full command of the situation (Dewey, 1897), it is important to make the competence transparent to aid the students to recognise how they can exceed their capacity. Present experiences build on past experiences, so it is possible to take past knowledge into use in multidisciplinary collaborations to solve an authentic and open task. Dewey was critical about studying facts and ideas bound up with the past as they give little help in dealing with the issues of the present and future. Dewey set no ends outside of the processes of education except growth (Dewey, 1897, 1916/1985). However, today, education and its formal institutions are responsible for communicating their ends and setting targets and individual assessment criteria. If the task of education is to serve the broad social purpose emphasised by Dewey, to help people be and act as more effective members of a democratic society (Dewey, 1916/1985), education should offer real-life opportunities to students, but at the same time be able to grade and assess learning. Therefore, the theoretical framework presented in chapter 2 of this dissertation actually forms one severe conflict: Pre-defined competences set as learning outcomes vs. Dewey's learning experience that has no fixed ends. Dewey could not tolerate the idea that educational authorities such as teachers would set fixed "ends" (Dewey, 1916/1985) to educational experiences, but the definition of competence and the competence-based curriculum in UAS requires such learning outcomes to be presented. Learning outcomes as "statements of what the individual knows, understands and is able to do on completion of a learning process" (ECTS Users' Guide, 2015) are set in the curricula. A balance between these two aspects is suggested based on the findings of this study and by acknowledging student agency as the previous experiences, context and competences of the student (cf. Eteläpelto et al., 2010). Designing the real-life activity systems that support the ends given by the competences, using the found competences as tools to frame the peer-assessment discussions and to help students recognise their own desires and learning aims would let students immerse themselves fully in their project work experience but still discover learning needs and outcomes both during and afterwards.

The (quantitative) measuring of innovation competence seems to be a mission impossible: How can, for example, flexibility (sub-study I) be measured without qualification of the construct by a psychologist? The self-assessment surveys were not found to be reliable methods in an innovation tournament context (sub-study II), but they

may benefit students in innovation projects that are not organised as gaming experiences. It is not possible to discover the usefulness of innovation tournaments in developing innovation competence in institutional contexts unless competence development can be assessed (sub-study II). Based on the findings from sub-study II, assessment cannot be a one-off post-project way of evaluating innovation competence and the produced product, service or other outcome. In sub-study III, students reported that the team used much energy in trying to understand what the team was capable of developing. Pedagogical tools are needed to make the individual competences in teams more transparent. Several competence development and measuring methods were co-developed during the Teacherforum process (sub-study II) based on the agreed criteria (sub-study I) to enable the sharing of personal strengths and weaknesses in the teams and to reflect on competence development from start to finish.

The assessment of innovation competence was found to be useful and important in every phase of the process. First, when a new multidisciplinary team starts working. If the teams are formed by students from different disciplines, they do not know each other before they start working together. To find out what the team is capable of doing, an assessment discussion is in order. Strengths, weaknesses and the development needs of team members can be discussed based on figure 4, and in this dissertation, this is suggested as relevant if the competence factors are applied to a more convenient workshop format and a pedagogical tool. Thus, the teachers piloted the “InnoCards” gamified workshop method that was produced based on the results from sub-study I and they found it usable for team use when assessing competence and competence development needs at the start, in the middle and at the end of the process (sub-study II). The assessment is not only the teachers’ responsibility, as Dewey notes that it is up to practitioners to set the ends and the criteria for practices (Dewey, 1916/1985). In this case the practitioners are not only students, but a whole network. Giving feedback to others and getting it in many phases was of utmost importance to the students’ learning experience (sub-study III). In sub-study III, the team members were strangers in the beginning. It became critical for them to rapidly learn about each other’s competence to understand what the team was capable of developing and where learning during the process would be mandatory.

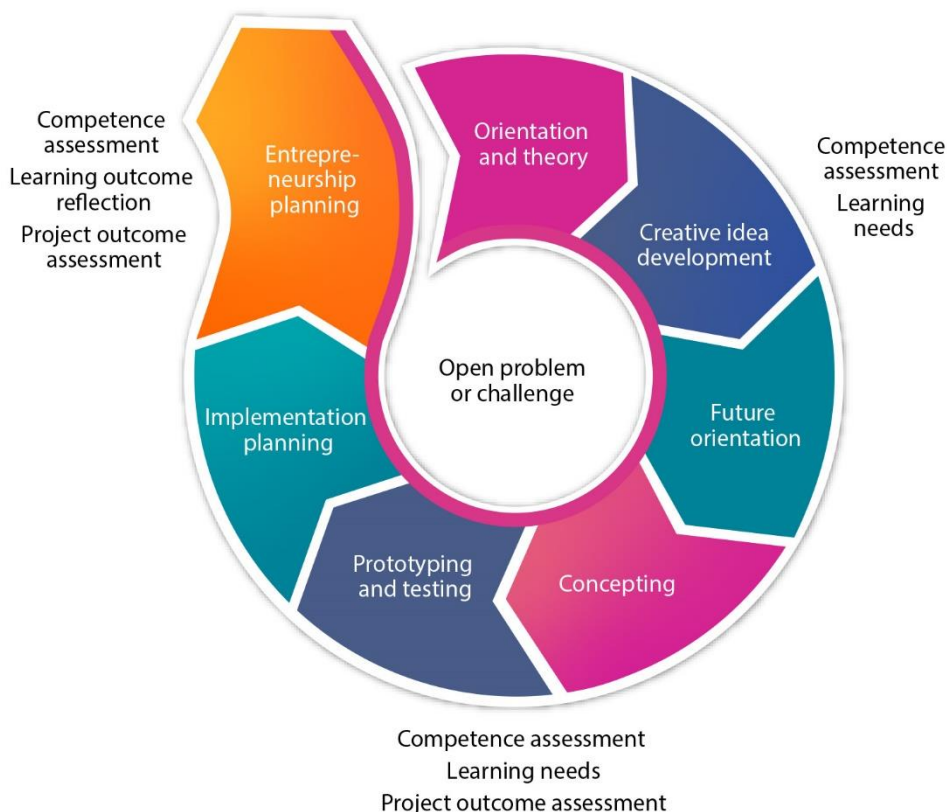
It is suggested, based on the sub-studies, that the teachers should organise or facilitate assessment by providing assessment opportunities at the beginning of the project so that the strengths, weaknesses and development needs become transparent in the teams. They should also organise or facilitate assessment in the middle of the project, so that students themselves are able to state the learning goals and steer their teamwork towards the maximum development of each team member, and for teachers to adjust the pedagogy and focus the team and individual student tutoring where that is needed. At the end of the project, assessment is likely important to address the experience, the innovation development process and outcome, learning and personal growth.



### 7.3 Factors related to the pedagogical process

Many innovation management and its process theories have parallel results concerning the “phases” in innovation processes (Baregheh et al., 2009; Eveleens, 2010). The phases teachers found important were “weekly rounds” that structured student work, either explicitly given to students to ease the pain of uncertainty found in sub-study III or used implicitly (i.e. to help teachers understand them and be able to tutor the teams for more complete outcomes). Based on the findings from the second sub-study, a model of an activity system was developed collaboratively in a teacher forum. It was organised in seven weekly rounds with weekly tasks: the orientation (future, innovation concept), idea, concept, prototype and testing, implementation, entrepreneurship and assessment rounds (sub-study II). The collaborative design of the phases met the precondition (i.e. it enabled the development of innovation competence found in sub-study I). In addition, teachers felt that this could increase understanding of the innovation processes for later application in working life (sub-study II). If students have internalised practical innovation development processes during their studies, they can be readier to apply the same process models later in their working lives. Their working lives would also benefit from innovation competence and more routine in developing new implementable solutions via networked collaborations (sub-study III).

The sub-study III participating students were able to conceptualise that they had learned innovation process phases such as *idea development* and *future visioning*, as well as advances towards more reasoned concepts, solutions crafted to a product or service prototype that is tested and to plan how the solution can be taken to the market or used otherwise by developing branding, marketing and budgeting solutions, and finally considering whether there would be a business or other type of entrepreneurship opportunity (sub-study III). These findings mainly promote the meaning of a direct experience resulting from a “path to innovation” as recognised process phases. In multidisciplinary innovation projects, the most important factor for learning seems to be the journey, not the actual project outcome (solution) or whether it is an innovation or not in terms of the definition of the word. In conclusion, organising an explicitly- or implicitly-facilitated pedagogical innovation process may promote more complete outcomes as it pursues implemented novelties.



**Figure 5.** A pedagogical innovation process, PIP (based on Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press).

These process phases differ only in that sub-study II suggests entrepreneurship and multiple assessment phases to be added to the pedagogical process. However, sub-study III found that, optimally, assessment is multilevel in nature, occurs in many phases and takes many forms, and thus the assessment should be integrated into all phases. Sub-study I supports these phases, except for implementation planning (defined as productisation and production planning), and marketing, sales and entrepreneurship planning skills. These were not found in recent research (see sub-study I), in other words implementation and entrepreneurship planning skills were not found to be individual innovation competences in recent research based on sub-study I. Orientation and theory were suggested as appropriate for the start of the process, but the theory was suggested to run through the whole project to give the practical tools to the learners in every phase of the development work. In conclusion, when planning a pedagogical innovation process based on sub-studies I–III, several phases and assessment and reflection opportunities can be considered (figure 5). The suggested pedagogical innovation

process phases based on the sub-studies are the orientation and theory, creative idea development, future orientation, conceiving, prototyping and testing, implementation and entrepreneurship planning phases. In addition, multiple assessment phases are needed during the process. Compared to previous innovation process models (Baregheh et al., 2009; Eveleens, 2010, see also Quintane et al., 2011), these phases support the previous findings, but offer a more descriptive way in which to formulate the model (cf. “post-launch” in Eveleens, 2010) and add a clear future orientation phase that was found to be needed in sub-study I to promote the competence outcome target. In this dissertation, an innovation process is not only understood as an idea development phase, but as a larger and more complete process from future opportunity recognition and idea development, to product or service development, to implementation, and even to entrepreneurship planning (cf. sub-study II-III) to bridge innovation and entrepreneurship.

## 7.4 Factors related to organising the activity and the teacher’s role

### *New networks and team multidisciplinary activate learning*

The strength of the multidisciplinary team formation within the empirical part of this dissertation was, for example, an opportunity for the students and teachers to form new networks and gain peers, which was found to be professionally crucial for them (sub-study II). The most meaningful network comprised of serendipitous meetings with other teams’ members from different fields and those external professional networks that were needed to complete the product in practice (sub-study III).

Multidisciplinary in teams was found to increase the variety of knowledge, perspectives and experience within a team, to allow for a wide variety of creative ideas and taking them into practice, and to provide wide networks (Aarikka et al., 2014) and complementary skills (Miettinen & Lehenkari, 2016; Pittaway et al., 2004), but it was also found that it may badly influence communication, collaboration and team integration (Ancona & Caldwell, 1992; Harrison et al., 2002; Keller, 2001). In sub-study III, multidisciplinary team formation allowed for multiple perspectives, skill variety, complementarity of knowledge and new knowledge interfaces while also introducing other disciplines. In addition, the diversity of team members may promote student self-management (sub-study II). If knowledge of other fields than one’s own content knowledge or discipline is required in the innovation process, then multidisciplinary team formation can promote this end. Multidisciplinary causes and gives an opportunity to learn content that is not possible to define in advance; that is, content that is not there yet (Engeström, 2016). This supports the aims of Dewey, as he set no ends outside of the processes of education, rather, it is its own end (Dewey, 1916/1985).

*The activity system should allow for real-life conflict and contradiction*

Much of the students' experienced learning was reported in diaries to relate to solvable conflicts and unusual, new situations caused by multidisciplinary and open tasks. While contradictions and tensions occurred, students had to solve them together. Conflicts and contradictions did not have a drastically negative effect, but they were reported as offering "newness" and a collaborative problem-solving environment in the team and an experienced opportunity for personal development (sub-study III). Although innovation is promoted by teamwork, multidisciplinary collaboration and external partnerships, for an individual student's learning experience it means navigating in uncertainty (see also Johnsen, 2016). However, in the data, this was often seen as an initiator of learning and not as a negative experience. Contradictions in teamwork were related to positively experienced personal identity development in terms of flexibility, self-esteem and self-management, but also to learning collaborative problem solving. However, too much conflict and new situations might cause a decrease in motivation and affect performance (Biffi, Bissola, & Imperatori, 2017; Bissola, Imperatori, & Biffi, 2017; Derry et al., 2005). The findings of sub-study II also found that too much heterogeneity in teams causes too much conflict and can affect motivation (sub-study II).

*The multidisciplinary composition of teams allows for complementarity of competence and enables students to recognise their own expertise*

The motivation to mix students into highly heterogenic teams was based on the idea that different competences complement one another in a diverse team (cf. Miettinen & Lehenkari, 2016; Pittaway et al., 2004). If some team members can write perfect documents, some can make a prototype and some can present well, the team therefore becomes stronger than one individual or a pair. Therefore, multidisciplinary innovation project work promotes the ability to recognise each other's competences and previous experience. Based on this shared knowledge, students can realise what the team is capable of and what they have to learn during the project. Students can learn to recognise and express their own and their team's strengths, weaknesses and development needs. Multidisciplinary teams enable students to better identify their own expertise. This potentially enhances the students' own ability to set learning goals by themselves and, as this is shared in the team, teachers and peers are able to identify competence gaps for more targeted support (sub-study III).

*Multidisciplinary team composition can allow for a shift from "I" thinking to "we" thinking*

Students found they had learned how to work responsibly and independently, both as a team member and as an individual, how to explicate and make use of other people's competence in new situations, ways to actively build and develop the team towards the best possible outcome and how to collaboratively communicate and negotiate within the team and with external customers (sub-study I). This supports the notions of Dewey when he emphasised the meaning of educational experiences that enable students to act

as valued, equal and responsible individuals (Dewey, 1916/1985). The pedagogical model suggested in sub-studies II and III requires much independent work in teams. The responsibility of supporting the weaker and less proactive students may shift to peers (i.e. to other team members). According to the teachers' experiences regarding sub-study II, the best-functioning teams found a way to support the weaker students by assigning the roles in teams to those who manage work and to those who perform the given tasks. This offered an opportunity for them to learn leadership skills such as coaching others, the ability to recognise competences, building team spirit, and negotiating the division of labour, but it was also an opportunity for the weaker students to get empowered to their full capacity and more (cf. Dewey, 1897). In addition, it may be fair to argue, based on the findings from sub-study III, that in a multidisciplinary innovation project, the thinking seems to have changed from "I" thinking to "we" thinking. The results show that students put effort into reporting about their learning to encourage and coach others, consciously changing their attitude for the benefit of the team's wellbeing, and even deliberately giving up leadership positions to help others learn if they felt they already were experienced in project management work (sub-study III).

*To develop an innovation offers an intention and an objective*

According to Spencer and Spencer (1993), competence always involves an intention, which is the motive that ignites action towards an outcome. The innovation outcome can be considered the intention for the development of competence, and thus a vehicle for learning. Individual innovation competence could serve as the basis for presenting relevant curricula, programs, learning tasks and tutoring when educating and fostering learning through innovation processes for innovation (sub-study I). From the student's perspective, the multidimensional and versatile learning experience promotes active agency and proactive recognition of the competence and its development needs during the collaborative process (sub-study III). After all, when regarding the innovation process as a learning platform, successful competency development during the process is the core target. The learning environment should be organised to support future visioning, facilitate idea generation and foster the creation of new solutions to authentic problems. It should also allow social interaction in the form of team projects to incorporate project management activities. Moreover, the learning activity should allow for the design of useful solutions and an introduction to other relevant disciplines.

As a conclusion from sub-study II, multidisciplinary and multi-grade team formation can support the development of social skills and flexibility. Competition in the tournament can support achievement orientation. Furthermore, authentic and open challenges from real working life potentially promote motivation and engagement. Success in competition and being a part of a competent team may support self-esteem.

### *Real open tasks from real working life allow for novel solutions and real concretisation and implementation*

The open task required much proactive initiative, responsibility, motivation and achievement orientation. Most students found that they learned how to tolerate uncertainty, to work responsibly and independently, both as a team member and as an individual, how to explicate and make use of other people's competence in new situations, ways to actively build and develop the team towards the best possible outcome and how to collaboratively communicate and negotiate within the team and with external customers. This potentially enhances the students' own ability to set learning goals by themselves and enhances the teachers in terms of them identifying competence gaps for more targeted tutoring (sub-study III). If the conflict and uncertainty is intolerable to some students, teachers could try to balance contradiction and motivation with tutoring.

Authentic and inspiring challenges from firms and organisations allow for real-life problems during the learning experience. Thus, the learning outcome cannot be anticipated. However, when understanding the competences needed in innovation projects, it is possible to formulate the task or challenge so that the whole innovation process (e.g. Eveleens, 2010) becomes possible. The task should allow the development of a novel solution (e.g. a product, service), all the way from idea to implementation, and it should interest, motivate and benefit from multidisciplinary. The negotiation between teachers and working-life representatives aids the optimal formulation of the open challenge.

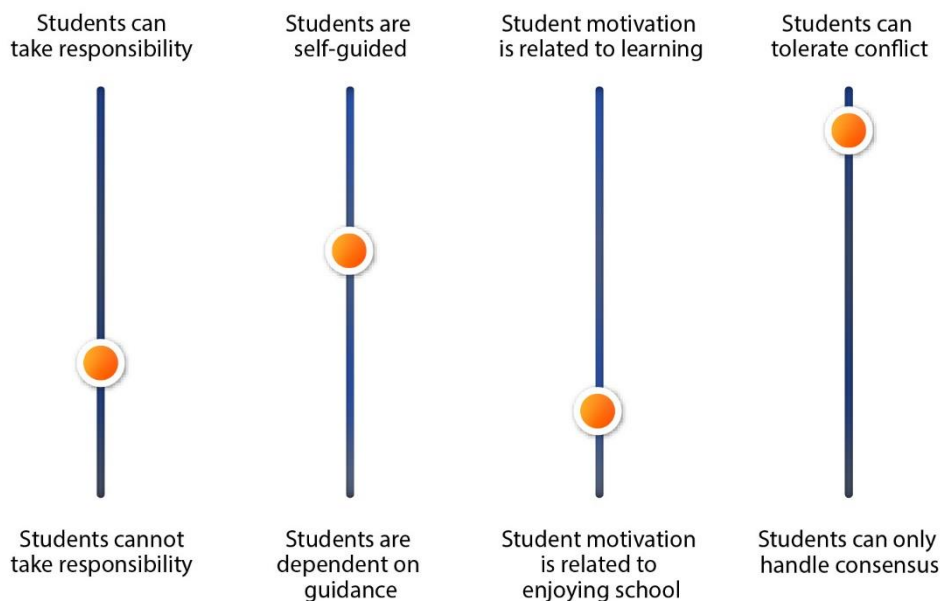
### *The teacher's role*

The tutoring process can be organised to address emerging competency gaps in relation to the desired learning outcomes. Teachers found the competence development objective to be necessary in the institutional context; the main goal is learning during the process and not just developing a successful solution for the company partner.

The learning subject is not only one individual student, as all parties in the network are faced with the same authentic, open, vague problem. The "learning subject" in the activity system (Engeström, 1987) is rather a collaborative network consisting of e.g. students from different fields, even from other grades and institutions, working-life representatives as partners, teachers from different fields than one's own, the end-users of the developed product, other teams and possibly other networks. If the project course is organised as a game (i.e. a tournament), then others are included in the process such as judges who boost the solution development work and evaluate competence development, a producer for organising the collaboration and events, and a manager to orchestrate the large organisation and its networks. In an innovation project, the whole collaborative network is faced with something new and nobody knows the answer to the open problem at the beginning. The system needs a facilitator to bring all members into collaboration. In addition, teachers are the only pedagogical experts in the activity.

However, learning can also be recognised by students for their peers if tools for this are available (see sub-study II: assessment tools).

Teachers are guided by their own preconceptions about what the learner and what the learning community is capable of, how much responsibility the learners can handle, how self-directed they are in their actions and how capable they are in setting their own learning goals. Teachers can be unwilling to “open the hidden agenda” (i.e. their pedagogical aims for and expectations of the participating students; sub-study II). However, teams could be capable of more future-oriented, concrete and more implementable outcomes if students were tutored more in the first phases such as in terms of their future orientation, and in the final phases related to implementation (i.e. productisation, production, sales, marketing and entrepreneurship planning).



**Figure 6.** In addition to competence factors, several pedagogical factors are crucial for teachers to recognise while facilitating learning to develop innovations in multidisciplinary teams (Hero, 2017; Hero et al., 2017; Hero & Lindfors, in press).

Teachers should be able to recognise different learning orientations and need to be able to adjust their tutoring accordingly. This may need experience in tutoring innovation development and can grow over time. Based on sub-studies II and III, several factors related to individual participants can be highlighted for teachers to recognise while tutoring multidisciplinary teams: the responsibility levels students can handle, students being dependent on teacher guidance, what student motivation relates to, and how much conflict and how many contradictory situations students can handle without losing

motivation. The variation can be understood metaphorically as sliding volume buttons representing the scales, only rarely coming to their ultimate end points: (1) students cannot take responsibility—students can take responsibility; 2) students are self-guided—students are dependent on teacher guidance; 3) student motivation is related to learning—student motivation is related to enjoying school; and 4) students can tolerate conflict—students can only handle consensus (figure 6). For example, the teachers have the opportunity to monitor the experience and ease the pain of conflict and contradiction if needed (cf. sub-study III, Engeström 1987, 1999, 2016, see also Lund, 2015; 2017; Jensen & Lund, 2016).

To conclude, multidisciplinary innovation projects described in sub-studies II and III are pedagogical ways to connect schools to the practices of society, as Dewey had already suggested. The individual differences between people and the heterogeneity of participants in the collaborative action were noted as a positive way in which to break down barriers (Dewey, 1916/1985). The teacher's role is, for example, to aid in recognising competence, offer tools for it, facilitate the solution development networks and work and balance conflict if necessary, to name a few.

## 7.5 Why is the concept of innovation useful in education?

Sub-study I found that definitions for innovation varied in the data but were well in line with each other. In most of the articles, innovation was clearly differentiated from creativity. According to Bruton (2011), a creative product is understood as a novel solution to a problem; once it has been applied to a valuable practical application, it becomes an innovation. According to Mathisen, Martinsen and Einarsen (2008), creativity refers to the development of novel and useful ideas and innovations towards the application of ideas. The majority of the articles defined innovation based on an outcome. Some of the articles defined innovation according to the process. E.g. Edwards-Schachter et al. (2015) and Waychal et al. (2011) followed Amabile (1996) in defining innovation as the successful implementation of creative ideas with a subsequent economic and/or social value generation in the market and/or society. According to Vila et al. (2014), innovation was the process of applying novel ideas and new knowledge to increase the efficiency in the production of goods and services. Bjornali and Støren (2012) and Waychal et al. (2011) defined innovation as a process of turning opportunity into new ideas and putting them into widely used practice. The common factors in the definitions in the data from sub-study I were creative and novel ideas and the obligation to implement them for the benefit of society or the market.

Considering the definitions of innovation proposed by Amabile (1996) and Sawyer (2006b), and the competences found in sub-study I, it is possible to draw several conclusions. Innovation, defined as a useful novelty made concrete and implemented to bring value, requires new and creative ideas that can be produced and implemented in practice to reach an outcome. It is possible to argue that creative thinking skills and



future orientation support the requirement of novelty in the outcome. It is also possible to argue that the requirement that the innovation be concrete is supported by making skills (designing, prototyping). The requirement of real-world implementation is supported by social skills (collaboration, networking and communication skills) and project management skills. As innovation processes were found to often be naturally or systematically organised as cross-disciplinary teamwork (Edmondson, 2013; John-Steiner, 2000; Sawyer, 2003, 2014), the personal characteristics of participants are arguably crucial. The findings from sub-study I supported this view.

If an “innovation” is a novel solution to an authentic challenge or problem that is made concrete and taken into use to convey real value, in optimal pedagogical design this should be set as a transparent and literal aim of the activity. Thus, the activity is intentional – it aims at a certain type of outcome. Competence development relates to the experience of a collaborative and multidisciplinary innovation process (i.e. the development work). An innovation *per se* as an outcome is not understood as any proof of learning. However, the concept gives a goal, intention and direction; namely, an object (or objective) to the actions, which is seen as an essential part of a collaborative activity (Engeström, 1987; Jonassen & Rohrer-Murphy, 1999; Nardi, 1996). In relation to learning, it aims at developing a certain type of competence that is valuable in all professional fields, as innovations are not only technical novelties aiming at economic benefits, but also valuable in other fields of society: in the ordinary life of an average citizen; in healthcare requiring savings and social added value; for local neighbourhood culture suffering from a lack of participation, etc.; and for big and small new solutions dependent on the user’s needs.

Based on sub-study III, innovation development seems to be internalised as something that students can participate in making, but it requires many different people and wider networks. The students found that they had learned innovation process phases such as idea development and future visioning, as well as advances towards more reasoned concepts. These are crafted to a product or service prototype that is tested. A plan is developed as to how it can be taken to the market by producing branding, marketing and budgeting solutions, and finally by considering whether there would be a business or other type of entrepreneurship opportunity. However, future orientation and implementation planning skills were weaker than other variables in the data from sub-study III were. This is thus a challenge for teachers to step in and support these phases. It is important to be able to grasp the whole process, as only in that way can the transfer to working life become possible. A clear process model can be internalised and thus be more easily taken into use later in one’s working life.

To conclude, “innovation” seems like a useful concept to be applied in educational settings: (1) when the outcome of students’ work is not required to be pre-determined: “Please, make a wool sock.” Instead, the starting point requires an open set up: “Winter is coming soon. What would you do about that?”; (2) when the students are encouraged towards creative outcomes with original novelty value and empowered to reach for their

full capacity and exceed it by learning; (3) when the importance of aiming at concrete and useful outcomes such as products, services, processes or other concretised artefacts is emphasised; (4) when the students are encouraged to plan the concretisation and implementation, either commercially or otherwise, to be taken into use to convey economic, wellbeing, social, sustainability, or other real types of value; and (5) when the value in authentic experiences is required to be grasped by students working as part of society, not only inside school buildings, learning together with their potential future employers and in real networks. These ambitious goals require multidisciplinary collaboration to produce a large number of high-quality original ideas and to collect the competence needed in such versatile and multistage projects. The concept in the educational context can thus be used to emphasise the bold aim of authentic development work in collaborative and networked education: competence for students and new products, services or other clever solutions for working life or society and its target groups in need.

## 7.6 Methodological considerations and limitations

This study applied a multi-method qualitative approach. Qualitative research approaches are sometimes criticised for being subjective and difficult to replicate (Creswell, 2009), but reliability is also seen as a poor measure to evaluate qualitative research because repeatability and consistency of the measurement is often not reasonable (Guba & Lincoln, 1994; Järvensivu & Törnroos, 2010). The most important criterion to evaluate qualitative research is considered to be the validity that describes the credibility of the study and trustworthiness of the research (Guba & Lincoln, 1994). The overall trustworthiness of qualitative research should thus be evaluated based on naturalistic terms (i.e. *credibility*, *transferability*, *dependability* and *confirmability*; Guba & Lincoln, 1994).

The multiple data sources to study learning to develop innovations have offered an opportunity to advance validity (Cohen et al., 2007; Creswell, 2009; Denzin & Lincoln, 2005), to enhance *credibility*, as the three sub-studies investigated the phenomenon from different angles. The qualitative studies' findings are unique in their respective contexts, but *transferability* to other contexts may be possible (Collier-Reed, Ingerman, & Berglund, 2009; Creswell, 2009). Transferability is related to the *generalisability* of the data; that is, the extent to which the findings may be applicable in other contexts or with other participants (Collier-Reed et al., 2009). The results of this study can be transferred to other contexts by acknowledging the special characteristics of the participating students and the context. By adjusting tutoring, the suggested pedagogies can also potentially be applied to other kinds of multidisciplinary collaboration, different age groups, different contexts and even multi-grade contexts, as proposed in sub-study II.

*Dependability* concerns the extent to which the researcher provides readers with evidence that the research process has been logical, traceable and clearly documented.

The general part of the dissertation aims to provide transparent documentation with adequate information on the research process. *Confirmability* pertains to the extent to which findings are shown to be empirically trustworthy. The research process has been reported as explicitly as possible. Each article offered a complementary view to enable the understanding of the topic (see Dubois & Gadde, 2002). The strength of this process was that it enabled the creation of a more thorough picture (both theoretically and in practice) about the relevant factors of learning to develop innovations than a single view could covering only the opinions and experiences of the participants at a single point in time. Therefore, conducting a survey or interviews at a randomly chosen time would have been an inadequate method for collecting materials.

*Credibility* refers to the defensibility of the interpretations made from the data and the rigor of the process through which the findings have been obtained. Concerning the sub-studies, the methods to advance the rigor of the research process were reported in section 5.4, but the limitations need to be carefully considered before applying the results. Despite the bias control in the data-analysis phases in each sub-study, this dissertation research project has limitations that should be carefully considered before applying this research. In sub-study I, several limitations were noted. The first limitation was that the material was limited. Although a systematic approach was used to select academic articles for review, other researchers may be able to locate additional articles. However, this view is arguably true of any systematic literature review (Greenhalgh, 1997). As the material consisted only of peer-reviewed, academic articles, the lack of academic books, scholarly theses and other research could have potential implications for the results. One weakness is that, although a number of competency factors were identified, there was no one uniform view of competence that predicted innovation. An innovation and its emergence can be ultimately a phenomenon that cannot be predicted even with perfect competence of all participants. Its emergence may be preceded by such complex ecosystems that the effect of the competence of single actors can be only relative. However, organizing and facilitating such ecosystems may benefit from the shared understanding of related competences. The concept definitions of innovation varied, although the bias assessment was strict. Still, congruent factors were found in the definitions and these were well in line with the definition set for this review (see sub-study I).

Another potential limitation lies in the method used for the sample selection; in sub-study I, this method focused solely on the individual perspective despite the likelihood that the surrounding organisational, team-level factors and cultural settings would have strong effects on innovation. For example, this can be interpreted on the basis of the importance of the social interaction competences of individuals. Another potential limitation arises from the heterogeneity of the sample. The analysed articles varied greatly by context, sample size and type as well as by research strategy. The sample of the sub-study I consisted of both qualitative case studies and the quantitative analysis of large samples collected using different methods in a variety of cultures. Furthermore,

some articles were considered to be biased by the authors. However, while heterogeneity may have created some uncertainties in the analysis, the selected articles were not contradictory in terms of the presented results. The rigorous selection and extraction process ensured that each study was conducted with adequate scientific credibility within its own research genre. Thus, the heterogeneity of the sample can actually be considered a strength of this study because the results are supported by numerous methods collected in different cultural settings. There was a reasonable weight of research evidence to support the suggested findings to give direction to pedagogical processes (sub-study I).

In sub-study II, the research materials were limited. Only two pilot tournaments were designed based on the teacher meeting workshops. However, for a qualitative inquiry, the material was abundant and rich, and offered good visibility to the tensions and solutions that had to be confronted during one year of development work. The second limitation was that although a systematic approach to collect the video material was used and a transparent analysis process was applied, other researchers may have identified other tensions and solutions in the discussions. However, this view is arguably true for most video annotations when only one annotator is involved (Derry et al., 2010). If cross-annotation by several researchers had been carried out, the reliability could have been increased.

In sub-study III, the diaries only offered access to social service and cultural management students' views, in only one context with a special course outline. The diaries showed varied motivations in terms of participation. Most of the students seem to have been very engaged in the project work, but a few diaries expressed a lack of motivation and a lack of interest in writing a diary for some weeks. However, the diaries provided a rich view of students' reflections. The method produced a large number of experiences compared, for example, to materials where students crystallise their most essential learning experiences at the end of a project. This made it hard to determine what the most important learning experiences were but offered visibility to deeper sensations and feelings during the project. The phenomenographic method also has limitations, as other scholars would most likely have found different categories. Still, the two-reviewer analysis process offered more careful consideration due to several discussion and joint-reflection opportunities.

The main limitation of this study is the focus on multidisciplinary collaboration without studying the collaboration of students themselves by observing teams from a close distance. Competence and teacher and student experiences have been the main focus of the analysis, whereas deeper network and team perspectives would have been important as well. One weakness of this dissertation is the lack of theoretical background knowledge concerning the role of the teachers even if the role of the teacher was emphasized in one of the sub-studies (sub-study II). That delimitation was made, because teachers were in a role of developers of the activity system, and this study did not empirically investigate teachers while teaching. Teachers role is

thus more a finding based on sub-studies II and III as teachers are part of the activity system.

The literature about new product development processes and new knowledge creation, as well as the socio-historical and cultural-historical approaches to innovation development, might have been relevant and they were considered. Additionally, all five innovation project courses (three during sub-study III and two during sub-study II) where the empirical material was gathered involved the active participation of the researcher. This has affected the research results in the analysis phases and can be considered a limitation, as this has most certainly affected the results. Studying the phenomenon without active involvement might have produced different results.

To conclude, the methodological aim to develop tools to investigate and develop further different types of innovation learning programs can be now summarized. First, the perspectives model to study learning to develop innovations can be used as a tool to plan a research project (figure 2). In this case, despite the limitations, the methodological combination of a systematic review, the ASA of the teachers' development process and the thick diary material of the student learning experience proved to be a valid choice to study learning to develop innovations. A systematic review offers a solid ground to present what competencies are considered to form individual innovation competence as a whole. This can be something different e.g. in 2020-2030 than it was in the research published 2006-2015 as investigated in sub-study I of this dissertation. In addition, the ASA analysis method (Yamagata-Lynch, 2010) offers visibility to the activity system design, especially to reveal the tensions and contradictions encountered by the developer participants and to understand the activity system as a whole. However, this study was only one special attempt to understand one special program, and only in its collaborative development phase. The student diaries as a research material offered rich visibility to the program as experienced by the students. This is especially healthy in studies of ultimately challenging programs to understand the forms and levels of contradiction and conflict when members of different organisations, schools and universities work together (cf. Engeström, 2001). This combination offered in-depth visibility to the phenomenon from different angles. In addition, the individual innovation competence model (IIC, figure 4) and the pedagogical innovation process model (PIP, figure 5) may offer a methodological tool to study different programs. Quantitative survey methods or interviews would have offered only a snapshot of a certain timeframe and potentially a more superficial understanding of the matter under consideration.

## 7.7 Theoretical considerations and practical implications

In previous studies on university–industry innovation collaboration, universities have been seen as partners who are mainly responsible for research (Ankrah & Al-Tabbaa, 2015; Mäkimattila et al., 2015; Rantala & Ukko, 2018; Slotte & Tynjälä, 2003). This dissertation has shown that educational institutions can be the organising, catalysing and

driving members of the innovation ecosystems in the area, if the activity system formed as a networked collaboration also promotes student competence development. This requires educational institutions and their teachers to be able to take an active, but supportive role in organising and tutoring the activity so that the multidisciplinary collaboration becomes possible. Based on the findings in this dissertation, and the found factors for learning to develop innovations, this study thus contributes and offers practical solutions towards the innovation-related targets set for education (e.g. European Commission 2012, 2017). The innovation work in university–industry collaboration should also be evaluated in terms of the benefit it brings to students, not just to organisations. The students should “sit in the driver’s seat” and lead the novel product development projects aided and challenged by their working-life partners, networks and teachers, and they should actively collaborate for novel, implementable solutions. The benefit of the produced solutions (i.e. products, services, etc. prototyped and implemented or with concrete implementation plans) and learning within the networks and during such collaborative activities will benefit both parties: The whole community is faced with new problems to be solved and nobody has the right solution. The whole community is the learning subject (cf. sub-study II).

### *Theoretical considerations*

This dissertation adds to the previous research with a multi-fold theoretical and practical view of learning to develop innovations that crosses the boundaries of innovation management research and education research. It offers theoretical insights into the phenomenon from three perspectives: the learning outcome (i.e. the competence needed in developing innovations) (e.g. Arvanitis & Stucki, 2012; Avvisati et al., 2013; Bruton, 2011; Chatenier et al., 2010; Edwards-Sachter et al., 2015; Montani et al., 2014; Nielsen, 2015; Waychal et al., 2011; Vila et al., 2014); learning design (i.e. the real-life activity system formation) (cf. Engeström, 1987; Jonassen & Rohrer-Murphy, 1999); and the learning experience (i.e. how the learning in the activity system is experienced) (cf. Dewey, 1897, 1916/1985, 1938/1997). Innovation competence has not been defined explicitly based on systematically-collected academic research as an individual-level competence (as opposed to an organisational-level competence) entity while acknowledging that innovations are developed in collaborative, multidisciplinary and often networked activities and need special pedagogies and tutoring. In addition, it adds a theoretical and practical view of multidisciplinary development project pedagogies that are suitable for application in different contexts considering the limitations.

The theoretical aim was to deepen the understanding of learning as an experience in the border zone of school and society, to open up the concept of innovation from many points of view to educational discourse and to conceptualise a framework to study learning to develop innovations. This study has offered three models to understand learning to develop innovations. First, it offers a theoretical framework to study the phenomenon (figure 1). That framework can be used further to investigate other cases in other contexts. Second, based on the findings, this study offers a theoretical model on

individual innovation competence to be considered as a framework for planning assessment criteria, assessment methods and practical activities for innovation projects (figure 4). The model adds to the previous research (see sub-study I) on individual innovation competence, mainly regarding implementation planning skills such as productisation, sales, marketing and entrepreneurship planning skills. Based on the findings in this study, the innovation competence model is mainly recommended for use in collaborative assessment practices and for designing the activity system, and not for measuring single competence variables (e.g. with a psychometric emphasis on the quantitative level). Third, this dissertation suggests a pedagogical innovation process model to be used while planning the authentic activity system and for teachers to use as an explicit or implicit guide to follow to promote both innovation competence development and the novel solution development in the same project design (figure 5). This model adds to the previous research on innovation pedagogy (see section 2.6) with a structured theory to be applied in further empirical research, and to compare and design better process theories. However, it should be noted that as the concept implies, it looks at the process from institutional and teachers' perspective; for students the process would be an authentic experience as sub-study III demonstrated (see Cumming & Maxwell, 1999; Fook & Sidhu, 2010; Macht & Ball, 2016). Fourth, this study suggests a model for teachers to adjust their pedagogies and tutoring during the learning activity (figure 6). These adjustments may be necessary when the teams are heterogenic and the networks offer a challenging environment for the students' development work and learning within it.

### *Practical implications*

Several implications for pedagogy and curriculum development can be deduced if the limitations of the study are taken into account. From the practical point of view, based on these models, innovation project pedagogies and curriculum design could be modularised and applied in different contexts (e.g. with children, elderly people and with even more heterogenic teams than those presented in this study). The curriculum design should enable such activities that promote the entire process, from idea phases and future thinking, all the way through to implementation of the novel solution. Without the possibility of grasping all the critical phases, the activity resembles ideation or invention processes and many opportunities for learning are omitted (sub-study III). The optimal pedagogical innovation process can be designed to be an authentic and multidisciplinary open task-based learning environment following an innovation process. In this process, collaboratively-created ideas are transformed into a concrete end result, prototyped and tested, and implemented to convey value in the surrounding world through interactions in a networked community. For the purposes of learning, an innovation project cannot aim only at idea development, which is what short innovation tournaments and idea workshops generally do (e.g. Duverger & Hassan, 2007). It offers a concrete tool to aid students to grasp one useful process model as a whole. Students can later apply it in their working lives to ignite and catalyse innovation development work.

The role of tutoring is critical in many senses. Teachers should have their “fingers on the pulse” of teams and students needing support to ensure optimal learning outcomes. The teachers seem responsible for the deep comprehension of the innovation process so that it can be transferred later to working life by future professionals (sub-study III). Gaps in their ability to conceptualise future thinking as well as plan the implementation of the solution were found in sub-study III, but this was emphasised in the research article material of sub-study I. Students would possibly benefit from more concrete help from teachers in these phases, at least to grasp the opportunities. The teachers have the opportunity to monitor and control the experience and ease the pain of conflict and contradiction if needed. Too much conflict and new situations might cause a decrease in motivation and affect performance (sub-study III). The teacher’s role is not to make her/himself not needed, but rather, to take an active role. As students are highly immersed in the project work, teachers should be active in facilitating networked collaboration and helping students realise what they can learn, what they have learned, how the learning experience needs to be adjusted during the project work by facilitating reflection and collaborative assessments and actively building the networks and optimal conditions for learning with the students.

The teacher can translate practical work into understanding the professional competence developed during the project. Teachers should have the competence and tools to recognise individual competence, competence gaps and learning needs. The study suggested that an individual’s sense of his/her own competence could be aided by team workshops, making individual strengths, weaknesses and development needs more easily and openly understandable to all team members. By adjusting tutoring (see figure 6), the suggested pedagogies can potentially also be applied to other kinds of multidisciplinary collaboration, different age groups, different contexts and even to multi-grade collaboration, as proposed in sub-study II. In multidisciplinary innovation projects, learning is based on students’ previous disciplinary knowledge and experience, and while bringing it into use in the team, the student learns from his/her own starting point.

Based on this study, it can be argued that the term “innovation pedagogy” is a useful and valid term to be applied when the aim is to define and practice innovation development activities as purposive cultural interventions in networked and multidisciplinary collaborations for human development informed and shaped by the real values and history of the society (cf. Alexander, 2008; Daniels, 2007; Edwards, 2001) and when the target is to develop a novelty made concrete and implemented to convey value (cf. Peschl et al., 2014; Sawyer, 2006b). Pedagogy is thus not only a matter of teaching methods and practice. Innovation pedagogy also includes the wider arrangements such as study materials and other pedagogical tools, grading and assessment practices, the distribution of authority, the organising of time and space, and implicit or explicit ways of communicating, as presented in this study.



Overall, this dissertation provided in-depth knowledge about the experienced factors related to learning to develop innovations, but it did not provide insights into whether innovations can be made by students, nor did it prove that students learned to develop innovations. But this was not the aim either. The intentional aim and objective towards a real innovation offered a learning experience that was unique in nature and different for each student and allowed for the right types of competence development and more (i.e. competences needed to develop innovations).

## 7.8 Future research

Based on the findings in this dissertation, several areas for future research can be identified. First, the large competence entity (figure 4) should be further investigated. It is designed based on 10 years of research in organisational and educational contexts (sub-study I) and an empirical diary study of  $N = 74$  student participants in multidisciplinary innovation projects (sub-study III), but its applicability in the suggested collaborative reflection and assessment practices is still not thoroughly validated. It is not clear if it pertains only to the innovation process as defined in this study, nor can it be postulated that the variables presented are the only variables in any innovation process. Second, further research should be pursued to test the findings in different phases of the innovation process within the participating organisations (see Vila et al., 2014), but also in educational contexts. For example, project management skills, (which were not acknowledged at all in studies conducted in educational settings in study I) should be studied in educational facilities in the context of authentic, project-based learning for different age cohorts. Third, methods for assessing competence development should be developed and tested. Different types of self-, peer- and teacher-assessment methods could be designed to help the students understand competence gaps and opportunities for learning in projects. In team-learning contexts, making individual innovation competence transparent and understood to all members can have a positive impact on team success. The findings should also be compared with entrepreneurial competences, as the connection between entrepreneurship and innovation has been recognised (Gilbert, 2011; Gundry et al., 2014; Lewrick, Omar, Raeside, & Sailer, 2010; Maritz & Donovan, 2015), and this dissertation found that innovation and entrepreneurship were also linked, as innovation processes can lead to entrepreneurship planning (sub-study II), but the aims are different. The delimitations made for this study did not allow for thorough theoretical investigation on the relation of innovation and entrepreneurship, nor a comparison of the related competence. Therefore, the results of this study do not allow for further conclusions. Future studies could, however, focus on the border lines of these two phenomena.

Although the innovation competence criteria applied from sub-study I were found to be applicable and comprehensive in sub-study II, the assessment methods based on those criteria require further research, as sub-study III already found that there was a need to

modify the competence entity. The self-assessment surveys were not found to be reliable methods in the tournament context, but they can be applicable as pre- and post-self-assessments. Novel types of collaborative assessment methods need to be tested to equip teams with independent assessment tools to find out the strengths, weaknesses and learning needs in teams. The role of the teacher and peer-tutoring within the multidisciplinary team would likewise benefit from future research to understand more deeply how innovation can best be facilitated. The fifth area for further research is the different competences in phases of a pedagogical innovation process (cf. Standing et al., 2016). For instance, different competences are potentially needed in the development project management phase than in the preliminary future-oriented and idea development phases. In addition, it should be acknowledged, that the empirical part of this dissertation did not experiment with pre-planned phases, but these phases are suggested based on the findings of the sub-studies.

Sixth, future research agendas could focus on networked and multidisciplinary activity systems from the network and company perspectives to understand the full benefits for all parties involved. As innovations are linked with value creation (Sawyer, 2006b; Peschl, 2014; Quintane et al., 2011) it can give rise to conflicting interpretations of what different parties consider “valuable”. This dissertation did not focus on how to evaluate the project outcomes, ie. the products or services created by the multidisciplinary groups.

Seventh, future research should also focus on multi-grade group formation (Leton & Anderson, 1964), different types of team member selection methods and the potential benefits of the complementary of competences (cf. Miettinen & Lehenkari, 2016). As the sub-study II was conducted in an innovation tournament context, it is possible that the tensions and solutions were affected by the competition (sub-study II). On the other hand, competitions as learning environments are an under-studied area of research (sub-study II). In sub-study III students exhibited qualitatively different approaches upon their perceptions of the learning task and their conceptions of themselves as learners. Sub-study II found that knowledge is constructed through a social process involving collaboration and negotiation among groups of learners, which is why language and tools mediate the learning outcome. Therefore, further knowledge on how specific terminology impacts the development of competences would be interesting. Finally, future research should focus on team learning and learning of the whole participating network to be able to unfold learning facilitated by a networked multidisciplinary innovation pedagogy. Networked innovation activities and processes are potentially well applicable learning platforms in different educational contexts if the developed competences can also be seen as useful to students later in their lives. However, it is obvious that the study would have benefited from a more theoretically unfolded conceptualisation of the relation between the activity systems the students operate in and the learning outcomes, as the conceptualisation influence learning as shown in students learning outcomes (sub-study III). This would be an important line of future research to form deeper theoretical understanding.

Innovations are needed in all professional fields, and sub-study III showed that even non-technical students such as cultural management and social service students benefit from multidisciplinary innovation project learning. Hence, the most important next step would be to study the applicability of these pedagogical models in solving the problems related to the most wicked cultural, environmental and social problems.

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# Original Publications

**Sub-study I**

**Hero, L.-M., Lindfors, E., & Taatila, V. (2017)**

**Individual innovation competence:**

A systematic review and future research agenda

I

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## Original Publications

**Sub-study II**  
**Hero, L. -M. (2017)**  
**Innovation tournament as an activity system**  
**to promote the development of innovation competence.**

**II**

## Original Publications

**Sub-study III**  
**Hero, L.-M., & Lindfors, E. (in press).**  
**Students' learning experience in a multidisciplinary**  
**innovation project.**

**III**

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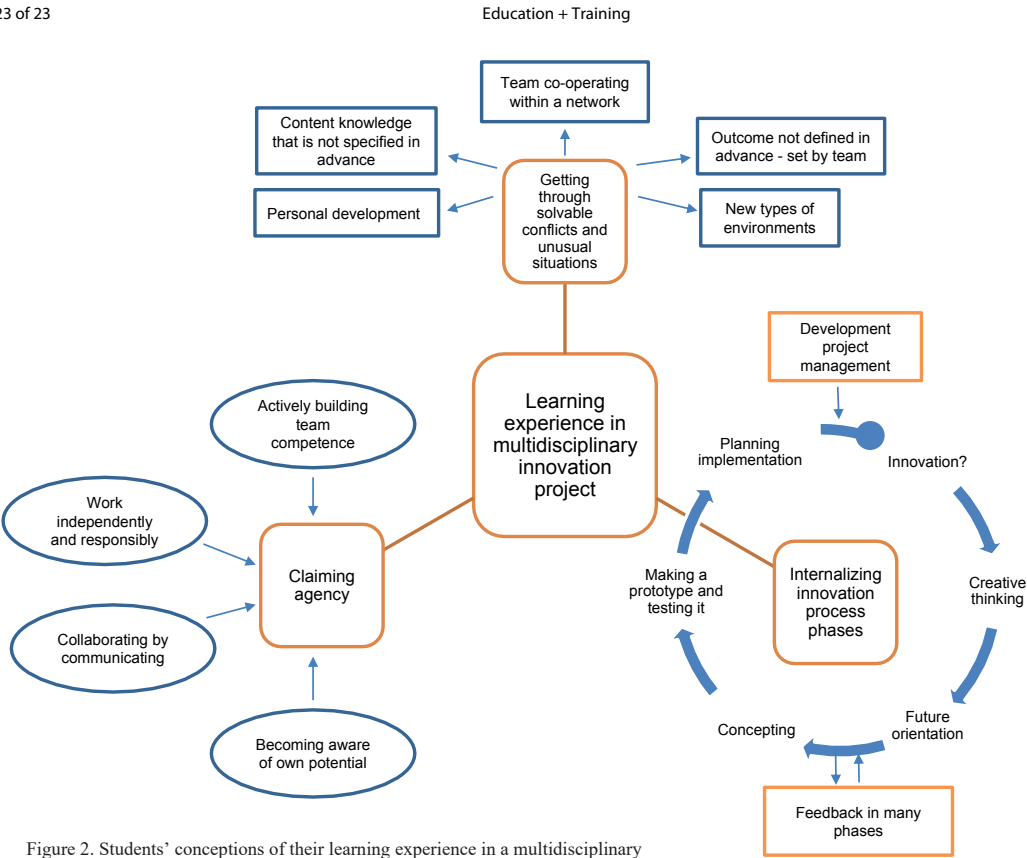


Figure 2. Students' conceptions of their learning experience in a multidisciplinary innovation project based on diary data (N=74 students).

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